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SEASONAL CHANGES IN THE WEIGHTS OF WOODCHUCKS

BY ROBERT L. SNYDER, DAVID E. DAVIS AND JOHN J. CHRISTIAN

ABSTRACT: An account of the seasonal changes in the weights of woodchucks, *Marmota monax monax*, is given for three age classes: (1) young of the year, (2) yearling, and (3) adult. The weight of the retroperitoneal white fat below the diaphragm and to the right of the dorsal aorta was taken as an index of the total amount of fat to illustrate the cyclic deposition and utilization of fat by these animals during the year. Woodchucks attain progressively higher weights each year for the first three years of life at least. They gain and lose weight periodically, gaining weight for about six months, then losing weight for the next six. The mean rate of increase in weight was highest, 16–20 grams per day (April through September), in the young of the year, but diminished to 14.7 grams per day (May through September) in the yearling class and 11.5–13.0 grams per day (April through August in the adult class. Total losses during the period of decline in weight ranged from 20 per cent of the prehibernal weight of young males to 37 per cent of the prehibernal weight of adult males. The rate of loss of weight immediately after hibernation was much higher than the rate during hibernation. Much of the fat stored prior to hibernation was still present in late winter when the animals emerged from hibernation. Adult males emerged from hibernation approximately a month before the females and the yearling males. Fat was utilized as a source of energy during the period of scarcity of food which followed hibernation. Fat was also an important source of energy for the females during the spring breeding season, as they utilized fat reserves during gestation and lactation.

The following account describes the seasonal changes in the weights of woodchucks, *Marmota monax monax*, and illustrates the cyclic deposition and utilization of fat by these animals during the year. Furthermore, changes in body weights and cyclic changes in the weights of the fat deposits are correlated with activities in the woodchuck's life history. An account of the seasonal changes in body weight and fat content is given for each of three classes of animals: young of the year, yearling, and adult.

Methods.—The animals studied comprised a population confined to an area approximately 2,000 acres in size located on the Letterkenny Army Ordnance Depot 4 miles from Chambersburg in south-central Pennsylvania. Snyder and Christian (1960) have described the reproductive cycle and the litter size of the woodchucks in this population.

A total of 1,700 individual animals was handled during the period from February 1957 to 16 May 1959. Of this total, 279 were young males of the

year, 316 were young females of the year, 527 were subadult or adult males and 578 were subadult or adult females. These animals, collected by shooting, box-trapping and netting, were weighted to the nearest ounce on spring scales. Figures were converted to grams and rounded to the nearest 5 grams.

Weights varied for the same animal, even on the same day, depending on the amount of food in the alimentary tract. The contents of the stomach may contribute 500 grams or more to the weight on occasion. For several reasons, no attempt was made to obtain the so-called vital weight by eliminating this and other factors, such as the weight of the embryos, etc. Emptying the stomach was impossible for live animals and laborious for dead ones. Many of the animals were marked with ear tags and released, then recaptured at intervals throughout the study period. Several weights of the same animal taken at different times during the three years therefore added considerably to the sample size. It was assumed that the stomach on the average contained an amount of food that was proportional to the total body weight; that is, a large woodchuck had a higher stomach capacity than a small one.

The retroperitoneal white fat in the right half of the abdominal cavity was taken as an index of the amount of stored fat (Plate I). The retroperitoneal fat below the diaphragm and to the right of the dorsal aorta was removed and weighed (± one gram) when woodchucks were sacrificed for autopsy.

Techniques for determining the exact ages of woodchucks have not yet been perfected. However, the young of the year were easily recognized by one or more of the following characteristics: small size; fine pelage; narrow, pointed muzzle; the long, narrow, pointed, unstained incisors; the undeveloped, unpigmented nipples and the undeveloped gonads. The young of the previous year were separated from the older animals during March and early April by using the same criteria. Especially helpful at this time was the condition of the incisors. But after the second week in April the separation could not be made reliably on many animals. Some of the older animals, for various reasons—poor health and stunted growth, for example—might be mistaken for yearlings.

The deficiencies in techniques were overcome by using only animals of known age in this study. This was accomplished as follows: All young of the year, as noted above, were easily identified. The age of woodchucks captured and marked as young of the year and subsequently recaptured in the following years was known with certainty. Also, animals trapped and marked one year as either yearlings or adults, then recaptured the next year or the year after, were known to be at least two years old. It was also possible to fix the age of certain animals captured during February, March and the first half of April as two years old or older, since at this time yearlings could be separated from those older. On this basis, three groups of animals were distinguished: (I) young of the year (1–9 months old), (II) yearlings (10–21 months old), and (III) adults (more than 21 months old). The adult class probably contained proportionately more two-year-old animals, since adult animals were removed

from the population by trapping and shooting and could only be replaced by reproduction.

Some of the woodchucks collected during the three-year period were therefore not included in this study of the seasonal changes in weight, because we were unable to determine if they were yearlings or adults. However, because so many of the animals of known age were marked and recaptured several times, the sample size for each of the three age classes was quite large (see tables). Certain animals occurred in all three age classes. Usually several days elapsed between captures of an animal, but only the first weight was used for animals taken twice on the same day (rare) or if the animal was taken again the next day. Only woodchucks in apparent good health were included in these statistics.

Each month was divided into two parts: (1) from the 1st to the 15th and (2) from the 16th to the end of the month. The body weights and the weights of the index fat of the animals collected within each period were averaged to give mean values for the period. Each point on the following graphs theoretically represents an average value for the middle of the semimonthly period. Confidence limits for the mean body weight and the range of the weights of the index fat deposits are given in Tables 1–6 for each period. A regression of weight on time was calculated for each age class for the period during the year in which increases in weight were linear (Table 7).

Growth of young woodchucks.—Most of the young are born within a relatively short period of three weeks from 1 to 21 April (Snyder and Christian, 1960) in south-central Pennsylvania. Three woodchucks immediately after

PLATE I

Photograph of woodchuck showing abdominal depot of fat.

birth weighed 30.2 grams (♀), 32.6 grams (♀) and 34.0 grams (♂), respectively. Hamilton (1934) weighed 20 individuals from birth to 12 hours after birth and found an average weight of 26.5 grams. Eleven animals less than 24 hours old examined by Grizzell (1955) averaged 27.2 grams in weight. Males and females apparently do not differ in weight at birth.

The earliest date a young woodchuck was captured away from its home den was 15 May. This young female weighed 425 grams, but was not the smallest taken. A male caught on 5 June weighed only 310 grams. The average weight of 24 young males collected from 16 to 31 May was 595 grams, while the average weight of 20 females taken then was 690 grams.

A statistical analysis of the data showed no significant difference between the mean weights of males and females during any period of the year; however, the males varied in weight considerably more than did the females. The standard deviation of the weights of males was 529 grams compared with 349 grams for the weights of females. Snyder and Christian (1960) give 10 April as the mean date of parturition in south-central Pennsylvania. Based on a mean birth weight of 27 grams, the average young woodchuck gained 687 grams from birth to 23 May, a period of 43 days. The approximate growth rate during this early period of life was 16 grams per day. This span corresponds almost exactly with the time that the young are suckled, as an average period of lactation of 44 days has been computed (Snyder and Christian, 1960). The calculated rate of growth during June increased to 20 grams per day for males and 18 grams per day for females and remained at these levels until October (Fig. 1). These differences between the rates of growth of males and females are not significant ($P < 0.10$).

TABLE 1.—*Seasonal changes in the weights of young woodchucks*

Dates	MALES			FEMALES		
	Number weighed	Avg. weight, g	±2 SD	Number weighed	Avg. weight, g	±2 SD
1–15 May	0	–	–	1	425	–
16–31 May	14	715*	(–1773)	20	703*	(5–1401)
1–15 June	39	1013*	(–2071)	30	973*	(275–1671)
16–31 June	48	1312*	(254–2370)	55	1243*	(545–1941)
1–15 July	52	1611*	(553–2669)	55	1513*	(815–2211)
16–31 July	62	1910*	(852–2968)	56	1783*	(1085–2481)
1–15 Aug.	31	2209*	(1151–3267)	37	2053*	(1355–2751)
16–31 Aug.	51	2507*	(1449–3565)	38	2323*	(1625–3021)
1–15 Sept.	47	2806*	(1748–3864)	36	2593*	(1895–3291)
16–30 Sept.	19	3105*	(2047–4163)	16	2863*	(2165–3561)
1–15 Oct.	5	2780	–	7	2950	(2250–3648)
16–31 Oct.	3	3155	–	3	2950	(2250–3648)
1–15 Nov.	0	–	–	1	2635	–
16–30 Nov.	2	2295	–	1	2635	–
TOTALS	373			356		

* The mean calculated from the regression equation was used in place of the actual mean of the weights taken during the period.

At the end of September the success of trapping young woodchucks dropped off sharply. Whether this drop reflected the withdrawal of the young into hibernation or whether it reflected only a change in the behavior of the animals to trapping was not known. We surmised that the first of the young animals commenced to hibernate (disappeared underground) on 1 October and that progressively more and more of the animals retired as time passed. Very few young woodchucks were observed during the last week of October and by 1 November the last of the young had retired underground. The average weight of the young prior to hibernation was close to 3,000 grams.

Growth of yearling woodchucks.—The growth curve computed for the yearling class (Fig. 2) is not as exact as that for the young animals. Large numbers of yearlings of known age were captured and autopsied or examined during March, April and May, but few after this time. So many of the young marked in the previous year were sacrificed during the breeding season to obtain data on reproduction that few were available for study later in the year. Also, data from two spring periods, 1958 and 1959, but only one summer and fall period, 1958, are included in this sample.

Both the males and females of the yearling age class emerged from hibernation during the last few days of February and the first week or so in March in this area. Only one yearling, a male, was captured during February. Emergence was probably spread over a three-week period, since only 12 yearlings

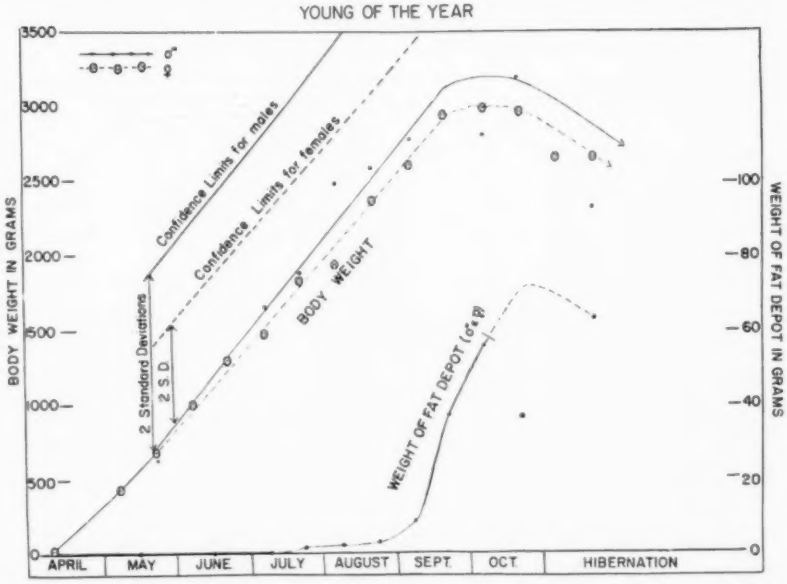

FIG. 1.—Seasonal changes in the weights of young woodchucks of the year correlated with changes in the weights of their right abdominal fat depots.

were captured from 1 to 15 March, but 45 during the last two weeks of March.

The males after emergence continued to lose weight until the end of March, while the females continued to lose weight until the end of April. A certain portion of the yearling females become pregnant (Snyder and Christian, 1960; 8 of 15 yearling females were pregnant) and this factor was apparently reflected in a longer period of loss of weight. The demands of bearing and suckling the young appear to be the major factors responsible for the significantly lower weights of the females from this point on. The growth rate of males and of females was the same throughout the summer, but the females never quite caught up to the males in weight.

The rate of increase in weight of both sexes from April through August calculated by fitting a line to the data in Table 2 was approximately 14.7 grams per day. The rate decreased somewhat from this point on, but definite conclusions were not possible because sufficient data were not available. The rate of growth of yearlings was significantly lower than the rate of growth of young woodchucks ($P < 0.001$).

Seasonal changes in the weights of adult woodchucks.—Adult male woodchucks (at least two years old) emerge from hibernation about a month before the immature animals and the adult females (Snyder and Christian, 1960). The first animals were observed above ground on 1 February. The numbers ob-

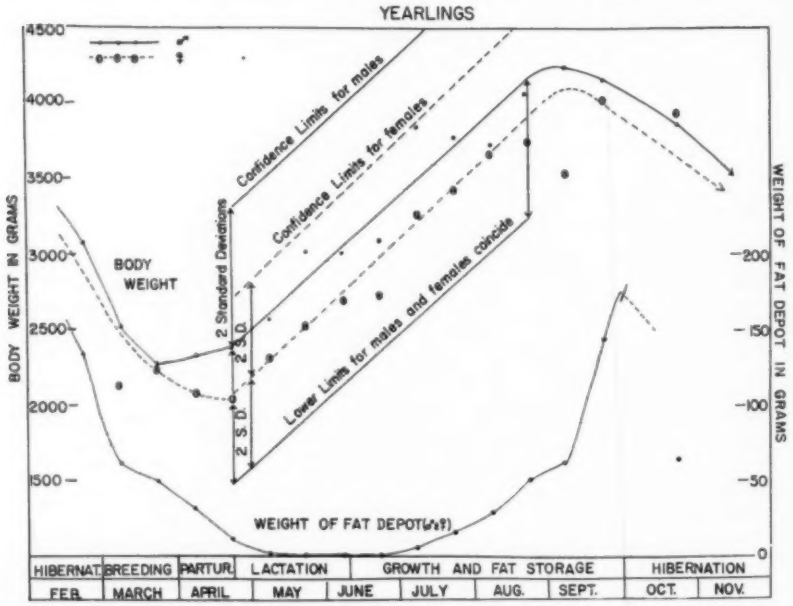

FIG. 2.—Seasonal changes in the weights of yearling woodchucks correlated with changes in the weights of their right abdominal fat depots.

served increased gradually throughout the month. Only two of the 25 woodchucks collected during February were females, one trapped on 22 February and the other on 26 February. The only yearling in this group, a male, was captured on 22 February (in a trap placed in the burrow to record the exact date of emergence from hibernation). Snyder and Christian (1960) reported that only 5 of 37 animals captured between 11 February and 2 March in this area were females.

It is not surprising, therefore, to see that the males weighed on the average no more than did the females during the last part of March and the early part of April (Table 3). The males continued to lose weight for some time after hibernation, presumably because of the absence of green food and the stress of reproductive activities (Fig. 3). The stomachs of animals collected during February were essentially devoid of food. The first green food, wild onion (*Allium* sp.) and bluegrass (*Poa* sp.), appeared in the stomachs of woodchucks collected early in March. The females conserved their stores of fat by remaining in hibernation longer and thus their weights were essentially the same as those of the males when they came to the surface around the first of March.

The females too lost weight after emerging from hibernation. Losses continued through March and April. The males commenced to regain weight midway through April, while the females' decrease in weight continued for approximately two weeks longer. The weights of males were then significantly

TABLE 2.—*Seasonal changes in the weights of yearling woodchucks*

Dates	MALES			FEMALES		
	Number weighed	Avg. weight, g	±2 SD	Number weighed	Avg. weight, g	±2 SD
16–28 Feb.	1	3060	–	0	–	–
1–15 Mar.	9	2535	(1945–3125)	3	2125	(1749–2501)
16–31 Mar.	24	2265	(1457–3073)	21	2230	(1376–3084)
1–15 April	47	2320	(1600–3040)	39	2070	(1562–2578)
16–30 April	42	2382*	(1450–3314)	41	2070*	(1440–2700)
1–15 May	51	2606*	(1674–3538)	41	2286*	(1656–2916)
16–31 May	20	2830*	(1898–3762)	23	2502*	(1872–3132)
1–15 June	15	3054*	(2122–3986)	12	2718*	(2088–3348)
16–30 June	7	3278*	(2346–4210)	10	2934*	(2304–3564)
1–15 July	10	3502*	(2570–4434)	6	3150*	(2520–3780)
16–31 July	4	3726*	(2794–4658)	25	3366*	(2736–3996)
1–15 Aug.	5	3950*	(3018–4882)	14	3582*	(2952–4212)
16–31 Aug.	6	4175*	(3243–5107)	18	3898*	(3268–4528)
1–15 Sept.	7	4225	(3293–5157)	10	3510	(2880–4140)
16–30 Sept.	1	4140	–	5	4005	(3375–4635)
1–15 Oct.	0	–	–	0	–	–
16–31 Oct.	1	3855	–	1	3940	–
TOTALS	250			269		

* The mean calculated from the regression equation was used in place of the actual mean of the weights taken during the period.

TABLE 3.—*Seasonal changes in the weights of adult woodchucks*

Dates	MALES			FEMALES		
	Number weighed	Avg. weight, g	±2 SD	Number weighed	Avg. weight, g	±2 SD
1–15 Feb.	6	4165	(3333–4997)	0	–	–
16–28 Feb.	16	3710	(2482–4938)	2	2820	–
1–15 Mar.	29	3670	(2766–4574)	14	3385	(2255–4515)
16–31 Mar.	68	3280	(2456–4104)	65	3350	(2426–4274)
1–15 April	45	3116*	(2106–4126)	64	3167	(2083–4251)
16–30 April	44	3311*	(2301–4321)	64	3084*	(2336–3832)
1–15 May	51	3506*	(2496–4516)	51	3256*	(2508–4004)
16–31 May	18	3701*	(2691–4711)	21	3428*	(2680–4176)
1–15 June	18	3896*	(2886–4906)	12	3600*	(2852–4348)
16–30 June	18	4091*	(3081–5101)	11	3772*	(3024–4520)
1–15 July	18	4286*	(3276–5296)	20	3944*	(3196–4692)
16–31 July	27	4481*	(3471–5491)	14	4116*	(3368–4864)
1–15 Aug.	12	4676*	(3666–5686)	17	4288*	(3540–5036)
16–31 Aug.	18	4871*	(3861–5881)	22	4460*	(3712–5208)
1–15 Sept.	21	5066*	(4056–6076)	14	4632*	(3884–5380)
16–30 Sept.	16	4935	(3925–5945)	14	4804*	(4056–5552)
1–15 Oct.	5	5190	(4180–6200)	2	4665	–
16–31 Oct.	2	4875	–	1	4735	–
1–15 Nov.	0	–	–	1	5390	–
16–30 Nov.	1	4735	–	0	–	–
1–15 Dec.	0	–	–	0	–	–
16–31 Dec.	0	–	–	1	4425	–
TOTALS	433			410		

* The mean calculated from the regression equation was used in place of the actual mean of the weights taken during the period.

higher than the weights of the females for the remainder of the year. The rate of increase in weight from May until September was 13.0 grams per day for males and 11.5 grams per day for females ($P < 0.05$). These rates of increase were, statistically, significantly lower than the rates of increase of the younger animals.

Storage of fat.—Hamilton (1934) first described the progressive accumulation of fat during the summer months. He wrote: "the first fat is laid down in the inguinal region. This spreads out and covers the hind legs, more especially the upper or outside portion. While fat works over the rump, and also commences on the shoulders, the two regions are joined finally by a common layer. The region of heaviest coating lies over the hind legs and the rump, where it reaches a thickness of more than half an inch (14 mm). *Coincident with this* is a rapid proliferation of fat about the genital organs and kidneys. When the animal is ready for hibernation, the internal organs caudad to the diaphragm are concealed in a white mantle of fat."

The retroperitoneal deposits of white fat in the abdominal cavity were selected as an index of the relative amount of adipose tissue. The fat to the right of the dorsal aorta and below the diaphragm was removed and weighed. The

omental fat and the intestinal fat were not included in the tissue weighed. The fat on the opposite side of the dorsal aorta was also weighed on several occasions to confirm that essentially equal amounts of fat were deposited in each half of the abdominal cavity.

A crude measure of the weights of the various deposits was made by removing and weighing all the white fat on an adult male autopsied on 4 October. This animal weighed 6,125 grams with an index fat weight of 236 grams and was judged to be in prehibernation condition on this date. The skin with the fat attached was removed from the carcass; then the fat was scraped off and weighed. The omental deposit and the fat stripped from the intestines were weighed separately. The total weight of the fat removed in this manner was 1,155 grams, 18.0 per cent of the total weight of the body. The index fat represented 20.4 per cent of the total weight of the fat, and the deposits of fat in the abdominal cavity accounted for more than one-half of the stored fat. The fat attached to the skin accounted for the next highest fraction, 32.8 per cent.

Brown fat accounted for only a small proportion of the total fat in this animal. Brown adipose tissue is located in the depression between the scapulae where it forms two symmetrical fat bodies on either side of the midline. Extensions of the interscapular fat bodies run forward between the superficial

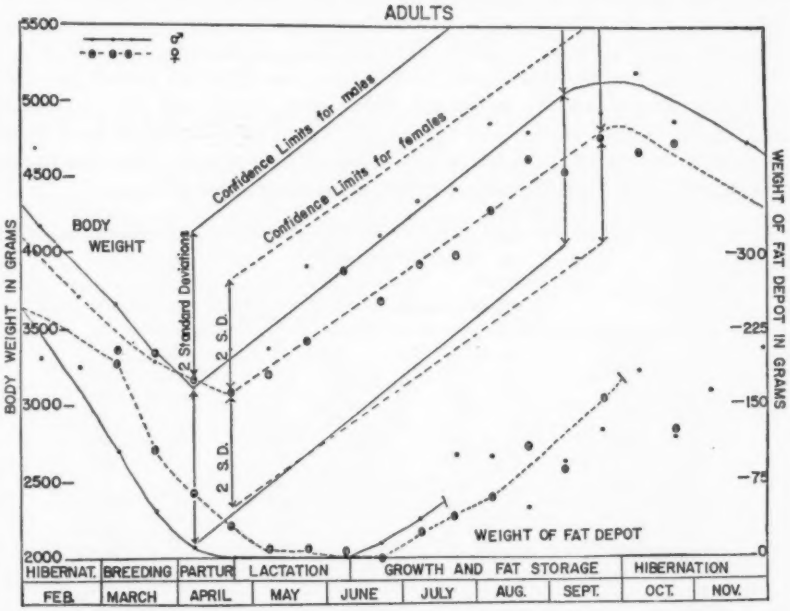

FIG. 3.—Seasonal changes in the weights of adult woodchucks correlated with changes in the weights of their right abdominal fat depots.

and deep muscles of the back, and are continuous with smaller masses in the axillae. Discrete lobules of brown fat also occur adjacent to the thymus and the pericardium, along the aorta and the carotid arteries, around the brachial plexus and around the vessels in the hilum of the kidney. Brown fat recovered from these sites in this animal weighed 19 grams. Thus, adding brown fat and allowing for fat in the muscles, the deposits of fat in this animal would probably account for at least one-fourth of its total weight.

Two other woodchucks were examined during October, a young female on the 11th and a yearling female on the 18th. Apparently neither of these specimens was prepared for hibernation, since the stores of fat of the young one accounted for only 14.9 per cent of the animal's weight and that of the yearling for only 8.1 per cent. The young one no doubt could easily store enough fat in two or three weeks to carry it through the winter. The yearling suffered from severe renal disease, which undoubtedly acounted for the low stores of fat. The index weight accounted for approximately 20 per cent of the total fat in each of these animals. Other deposits accounted for about the same proportions as those found in the adult male. A yearling male autopsied on 7 March contained 195 grams of white fat, 7.3 per cent of the animal's weight. The index depot (42 grams) made up 21.5 per cent of the total weight of the fat.

This evidence indicates that the fat deposits selected as an index of total fat weight accounted for approximately 20 per cent of the fat stored at any one time. There appears to be a uniform accumulation of fat in all parts of the body and the fat is uniformly depleted from all deposits as well. When the abdominal cavity was devoid of fat, there was little fat elsewhere. The interscapular and axillary brown fat bodies were small, and the pericardial and thymic regions were nearly free of fat. There were always at least small deposits of brown fat in the interscapular and axillary regions. Even the young woodchucks had small deposits of brown fat in these areas at birth.

TABLE 4.—*Onset of fat storage in young woodchucks determined by weighing the right abdominal fat depot*

Dates	Number weighed	Average weight of fat depot, g	Range in weights
May	9	0	0–0
June	24	0	0–0
1–15 July	24	0	0–0
16–31 July	21	1	0–9
1–15 Aug.	17	2	0–13
16–31 Aug.	5	3	0–7
1–15 Sept.	18	8	1–25
16–30 Sept.	5	36	16–81
1–15 Oct.	3	55	29–96
16–31 Oct.	3	36	31–41
1–15 Nov.	–	–	–
16–30 Nov.	3	62	34–76
TOTALS	132		

Accumulation of fat in the young of the year.—Storage of fat commenced during the latter part of July in the young woodchucks but did not accelerate much before the end of August (Table 4, Fig. 1). Accumulation of fat was rapid during September. Few specimens were collected immediately prior to hibernation, so we cannot state exactly how heavy the deposits of fat might have been at that time. Since approximately 25 per cent of the weight of the body prior to hibernation consisted of stored fat, weight increases during late September and early October were almost entirely due to the accumulation of fat. Evidently general growth ceased in early September and subsequent weight changes were due to the deposition of fat.

Accumulation of fat in yearling woodchucks.—The average semimonthly values for the weights of the index fat of the yearlings are given in Table 5. Because there was no significant difference between the sexes in regard to the weight of the fat deposits, the values for relative fat storage in the two sexes were combined to give a single curve in Fig. 2. The pregnant yearling females might deplete their reserves of fat much faster than do the nulliparous females and the sexually immature males, but we have no data on this point. So few yearling woodchucks were collected after midsummer that a finer analysis was not possible.

Fat deposition commenced during the first part of July in the yearling age class. Fat accumulated at a constant rate until suddenly in September a rapid acceleration in deposition took place. Gains of weight in September were probably due entirely to the accumulation of fat. Yearlings retired to their

TABLE 5.—*Seasonal changes in the weight of the right abdominal fat depot of yearling woodchucks*

Dates	Number weighed	Average weight of fat depot, g	Range in weights
16–28 Feb.	1	133	133–133
1–15 Mar.	10	61	27–108
16–31 Mar.	32	50	9–104
1–15 April	44	31	0–95
16–30 April	38	10	0–37
1–15 May	12	4	0–14
16–31 May	25	1	0–7
1–15 June	17	2	0–16
16–30 June	10	1	0–10
1–15 July	8	6	0–15
16–31 July	7	16	2–25
1–15 Aug.	2	29	18–39
16–31 Aug.	3	51	23–99
1–15 Sept.	8	61	10–115
16–30 Sept.	1	144	144–144
1–15 Oct.	0	–	–
16–31 Oct.	2	59	55–64
TOTALS	220		

subterranean chambers on approximately 1 October. Specimens taken after this date had abnormally small deposits of fat, which probably accounted for their late appearance above ground.

Accumulation of fat in adult woodchucks.—Females hibernate about a month longer than do the adult males; thus they did not deplete their stores of fat until the last of May. The adult males in contrast used up their reserves of fat by the last of April. Accumulation of new fat first commenced in the adult males during the first two weeks of June, while the females did not begin to store fat again until the first part of July (Table 6, Fig. 2). The points on the graph in Fig. 2 representing the mean weights of the index fat deposits are scattered quite a bit after July, the result of small sample sizes, especially for the males. The rate of deposition of fat appears to be more constant throughout the summer months, without the rapid acceleration which occurs in the young animals.

Adults commence hibernation by 1 October in this area. We have no evidence to indicate that the females remained above ground longer than did the males, as the sexes were captured in approximately equal numbers throughout September and October.

TABLE 6.—*Seasonal changes in the weight of the right abdominal fat depot of adult woodchucks*

Dates	MALES			FEMALES		
	Number weighed	Average weight, g	Range in weights	Number weighed	Average weight, g	Range in weights
1–15 Feb.	4	199	131–255	0	—	–
16–28 Feb.	6	189	123–280	0	—	–
1–15 Mar.	15	105	50–251	10	192	115–270
16–31 Mar.	35	49	3–142	41	106	5–227
1–15 April	17	12	0–89	49	65	0–174
16–30 April	12	5	0–21	18	32	0–84
1–15 May	5	5	0–18	9	8	0–32
16–31 May	7	5	0–25	11	8	0–39
1–15 June	15	3	0–16	6	0	0–0
16–30 June	7	12	0–46	8	0	0–0
1–15 July	7	36	8–85	9	24	0–55
16–31 July	2	100	68–131	1	38	38–38
1–15 Aug.	2	96	55–137	3	55	22–77
16–31 Aug.	3	47	32–72	2	107	91–124
1–15 Sept.	4	92	69–112	9	85	25–173
16–30 Sept.	3	125	88–195	7	155	97–221
1–15 Oct.	4	184	140–236	0	—	–
16–31 Oct.	1	116	–	1	122	–
1–15 Nov.	1	162	–	0	—	–
16–30 Nov.	0	—	–	1	265	–
1–15 Dec.	1	204	–	0	—	–
TOTALS	151			185		

TABLE 7.—*Regression equation for each age class for the period of the year during which increases in weight were linear*

Sex and age class	Period during which weight increase was linear	Regression equation*	SD x y
Young males	16 May–30 Sept.	$y = 415.7(\pm136) + 298.8(\pm30)\,x$	529
Young females	16 May–30 Sept.	$y = 433(\pm84) + 270(\pm17)\,x$	349
Yearling males	16 April–31 Aug.	$y = 2158(\pm123) + 224(\pm33)\,x$	466
Yearling females	16 April–31 Aug.	$y = 1854(\pm79) + 216(\pm16)\,x$	315
Adult males	1 April–15 Sept.	$y = 2921(\pm105) + 194.5(\pm18)\,x$	505
Adult females	16 April–30 Sept.	$y = 2912(\pm76) + 172(\pm13.5)\,x$	374

* 95% confidence limits for the constants a and b are given in parentheses.

Animals collected during October.—One cannot set an exact date for the beginning of the season of hibernation, because not all of the animals commenced hibernation at the same time. Occasionally a woodchuck was observed above ground as late as the middle of November. Dates of entrance into hibernation were determined on the basis of data from collected specimens and from observations in the field. All age groups of both sexes were represented in the sample collected during the month of September, but trapping success dropped sharply at the end of the month. The decline in trapping success might have been the result of behavioral traits of the woodchucks, spending less time above ground, less propensity for the bait, and so forth. One can only say that woodchucks retired to their underground chambers at this time in this area. Significantly, woodchucks recovered from excavated burrows in November were awake and active.

Thirty-eight animals were collected during October, 22 young of the year (11 males and 11 females) and 16 adults (11 males and 5 females). The young animals were generally healthy in appearance; however, the adults suffered from various afflictions—malocclusions (2), encysted tapeworm larvae (1), and diseases of the kidneys (all 16). The old animals, with two exceptions, were not especially fat (index below average). Hence, it would appear that woodchucks with sufficient stores of fat commenced their hibernal fast on about 1 October in this locality, but others for various reasons were forced to remain above ground much longer. Some of these animals no doubt perished

TABLE 8.—*Loss of weight during hibernation and during the period of scarcity of food immediately following hibernation*

Class	Loss of weight during hibernation		Loss of weight during period of food scarcity		% of total weight lost
	% of weight lost	Rate of loss, g/day	% of weight lost	Rate of loss, g/day	
Young males	12.3	2.4	8.1	15.7	20.4
Young females	24.0	4.3	5.8	11.3	29.8
Adult males	16.6	6.5	20.9	17.4	37.5
Adult females	29.0	8.7	6.0	6.3	35.0

during the winter because they could not accumulate enough fat. It has been reported in the literature that the young of the year are the last to hibernate. This is not entirely true, as we see above, since some of the young were prepared for hibernation soon after 1 October.

Large specimens.—Animals of unusual size are of considerable interest, especially to laymen. The largest woodchuck collected during the period of study, a male, weighed 7,150 grams (15 lb 12 oz) on 4 September. This animal when recaptured again on 5 March the following year weighed only 4,310 grams (9 lb 9 oz). The largest female weighed 5,755 grams (12 lb 11 oz) on 28 August. The weights of these animals are not unusually high when compared with the mean weights of the adults collected during September and October (Table 3), but they are the highest of the 1,700 animals (1,105 adults) handled during the study. Thus it would appear that woodchucks larger than these are indeed unusual specimens.

The largest young of the year were captured on 28 September, a male weighing 3,901 grams (8 lb 10 oz) and a female weighing 3,970 grams (8 lb 12 oz).

Loss of weight during hibernation.—The loss of weight during hibernation was of special interest. Actually both males and females emerged from hibernation in surprisingly good condition. A great deal of the fat stored the previous year was still present. The mean weight of the index fat deposits was still above 100 grams in the adult males during the first part of March and still above 100 grams in the adult females during the last part of March. Stores of fat were obviously an important source of energy during the breeding season when green foods were not abundant. The breeding males especially rely on these stores during February, since our observations show that they eat little if any at this time. Females utilize this fat during the gestation and lactation periods.

Table 7 shows the losses of weight during hibernation and during the period of scarcity of food immediately following hibernation for both young and old of the two sexes. These measures of weight loss were calculated by averaging the weights of animals captured just prior to hibernation and then subtracting the average weight of the animals weighed soon after emergence. The hibernal weight loss for young males was calculated for the period from 8 October to 8 March (150 days), for young females from 8 October to 23 March (165 days), for adult males from 1 October to 8 February (128 days) and for adult females from 1 October to 8 March (158 days). The weights of young males and females collected between 16 September and 31 October were averaged to obtain a mean weight prior to hibernation, while the weights of adult males and females captured between 16 September and 15 October were averaged to arrive at the same value for this age class. Average weights in the spring for all groups were taken directly from Tables 1, 2 and 3.

This analysis emphasizes one point in particular: the rate of weight loss immediately after hibernation was much higher than the rate during hibernation,

a simple testimonial to the efficiency of the physiological mechanisms of hibernation. Total losses during the period of decline in weight ranged from 20.4 per cent of the pre-hibernal weight of young males to 37.5 per cent of that of adult males. The females, according to this analysis, lost a higher proportion of their pre-hibernal weight during hibernation than did the males. The adult females hibernated much longer than did the adult males and there is also the likely possibility that the females, both young and old, were awake in their burrows some time before they appeared above ground. The young males lost only 12.3 per cent of their weight during hibernation and commenced to regain the lost weight within a month. The decline in weight of the young females as a class, as was pointed out earlier, continued for nearly a month longer than the decline in the young males. The adult, sexually mature males lost a significant portion of their weight after hibernation, but this is understandable, since the stress of active living during late winter without food and the stress of reproductive activities must have been severe.

In general, it may be said that the metabolic rate of animals in hibernation is between 1/30 and 1/100 of the "resting" metabolic rate of animals in the homeothermic state (Lyman and Chatfield, 1955). Benedict and Lee (1938) found that the weight loss of woodchucks during the time the animals were actually hibernating amounted to 0.2 gm/day/kg. Kayser (1952) has shown that the weight loss of European ground squirrels during the total period of hibernation is dependent on the length of time the animal is awake during the period. Thus a ground squirrel which hibernated for 4,126 hours used a calculated total of 70 calories, while during the 330 hours that it was awake it used 597 calories. Thus, in the present study the calculated rate of weight loss during hibernation is higher than that found by Benedict and Lee (1938), but the period for which the losses were calculated did include times when the animals were awake and the methods used to calculate these losses were very crude compared with the methods of Benedict and Lee.

Weight as an indicator of age.—Confidence limits (95%) for the mean weight found during each semimonthly period were calculated for each age class (Tables 1–3). Also parallel lines, either two standard deviations above or below the fitted lines, are drawn on Figs. 1–3. Confidence limits for young males and yearling males overlap slightly beginning about 16 June, while the limits for young females and yearling females overlap only during September. Thus, weights as a criterion of age would be useful to separate the young of the year from the older woodchucks. Young woodchucks never match healthy adult woodchucks in weight and only the heaviest young animals weigh as much as the lightest of the yearling animals. Another characteristic, for example an examination of the incisors to note the presence or absence of stain, used in conjunction with weights should enable one to identify the young of the year with little error.

Nearly all of the yearling females that weigh less than average weigh less than the smallest of the adult females. However, the lower limits of the weights

of adult males are well below the average weights of the yearling males. Hence, weights would have only limited application for separating yearlings from adults.

CONCLUSIONS

The woodchuck accumulates stores of fat during the summer which are metabolized during the winter and early spring. This fat is an important source of energy not only during hibernation but for a time after emergence when food is scarce. Thus, the animal gains weight steadily for about six months, then loses weight for the next six months. This cyclic change in weight is repeated again and again as long as the animal lives. Increases in weight are due to general growth and deposition of adipose tissue, while decreases in weight occur when growth ceases and the fat is utilized.

It would appear that woodchucks attain progressively higher weights each year for the first few years of life, at least. The data show a gradual diminution in the rate of increase for the first three years of life. However, woodchucks must grow for one or more years beyond the third year of life, as the average weight in the fall of animals in the adult age class is still less than the weights attained by the largest specimens collected. One assumes that these large specimens are not just two- or three-year-old animals that have attained unusual size, but rather that they are four or five years old, or older.

Males varied considerably more in weight than did females, but we cannot offer an explanation for this difference.

ACKNOWLEDGMENTS

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GEOGRAPHIC VARIATION IN NEW MEXICAN CHICKAREES

By James S. Findley

Abstract: Studies of geographic variation in southwestern chickarees, *Tamiasciurus hudsonicus*, revealed that the animals vary in size and in several aspects of their color. These characteristics vary independently. Most strongly differentiated populations inhabit southern mountain ranges peripheral to the main geographic range of the species. An explanation of this finding is proposed.

My studies of the biogeography of southwestern montane mammals included an investigation of geographic variability in the red squirrel or chickaree, *Tamiasciurus hudsonicus* (Erxleben), because this animal is an obligate inhabitant of boreal forests in the Southwest, and because studies of the animal may contribute to an understanding of the history of the biota of which it is a part.

The work was based mostly on specimens collected in the summers from 1956 through 1959. This field work was supported in 1956 by the University of New Mexico Research Committee and in the subsequent years by Grant No. G-3219 from the National Science Foundation. Some loan material was made available to me by Donald F. Hoffmeister, University of Illinois Museum of Natural History, and E. Lendell Cockrum, University of Arizona Department of Zoology, to whom I am most grateful.

Most mountain ranges in New Mexico which reach 9,000 feet in elevation are high enough to support extensive stands of trees of the genera *Pseudotsuga*, *Picea* and *Abies*, and also support colonies of red squirrels. This habitat has a disjunct distribution in the state, as do the squirrels. On some mountains the animals are rare or absent. None has been recorded in the Magdalena or Datil Mountains. Also the squirrels are not known to occur in continental Mexico or in the northern extensions of the Sierra Madre Occidental, such as the Animas Mountains in Hidalgo County, New Mexico. I know of no place in New Mexico or Arizona where the red squirrels occur in ponderosa pine (*Pinus ponderosa*) forest in the absence of trees of the aforementioned genera.

MATERIALS AND METHODS

A total of 233 animals was examined. Most of these squirrels are preserved as standard museum study specimens in the University of New Mexico Collection of Vertebrates.

Cranial size and proportions, bodily size and proportions, and color were analyzed. Variation in size of the animals as expressed by condylobasilar length is shown in Fig. 1. One of the ways in which color of red squirrels varies is in the relative amount of the guard hair which is taken up with black bands as opposed to yellow or reddish bands. Bands on ten or more hairs from each specimen in adult summer pelage were measured and darkness of each population was expressed as a percentage of the length of hairs taken up with black bands (Fig. 2). The color of the squirrels also varies on a red-yellow scale. Each specimen was ranked on this scale and degree of redness

or yellowness was expressed as a number from 1 (yellow) to 4 (red), as shown in Fig. 3.

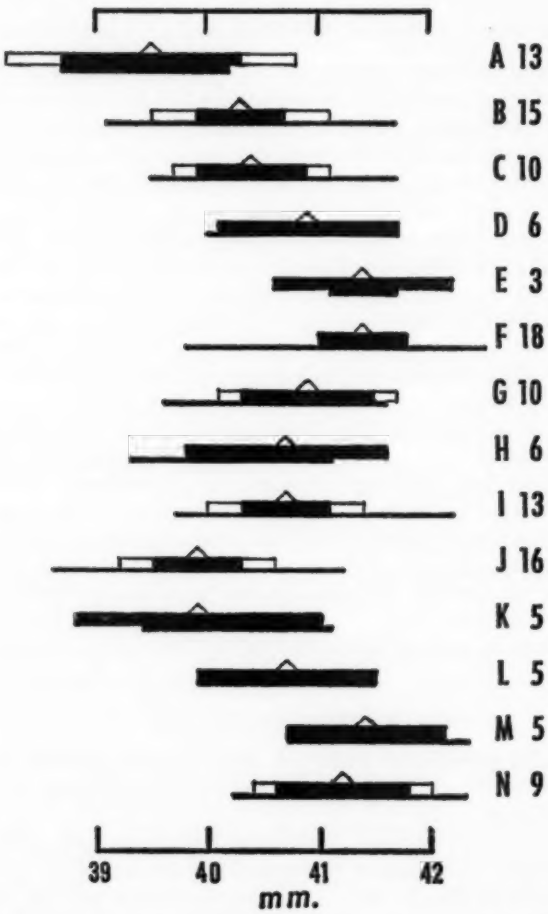

FIG. 1.—Size variation in southwestern red squirrels as expressed by condylobasilar length of skull. For each figure, arithmetic mean is indicated by the apex of the pyramid, solid black rectangle encompasses the 95 per cent confidence limits of the mean, open rectangle extends one standard deviation on either side of the mean (where no open rectangle is seen, the 95 per cent confidence limits exceed one standard deviation), horizontal line at bottom of figure represents extremes. Letters refer to localities on map, Fig. 3; numbers at right margin show number of specimens in each sample.

SPECIMENS EXAMINED

The specimens mentioned in the following list are those upon which the study was based and are in the University of New Mexico Collection of Vertebrates unless followed by the initials UA (University of Arizona, Department of Zoology) or UI (University of Illinois Museum of Natural History).

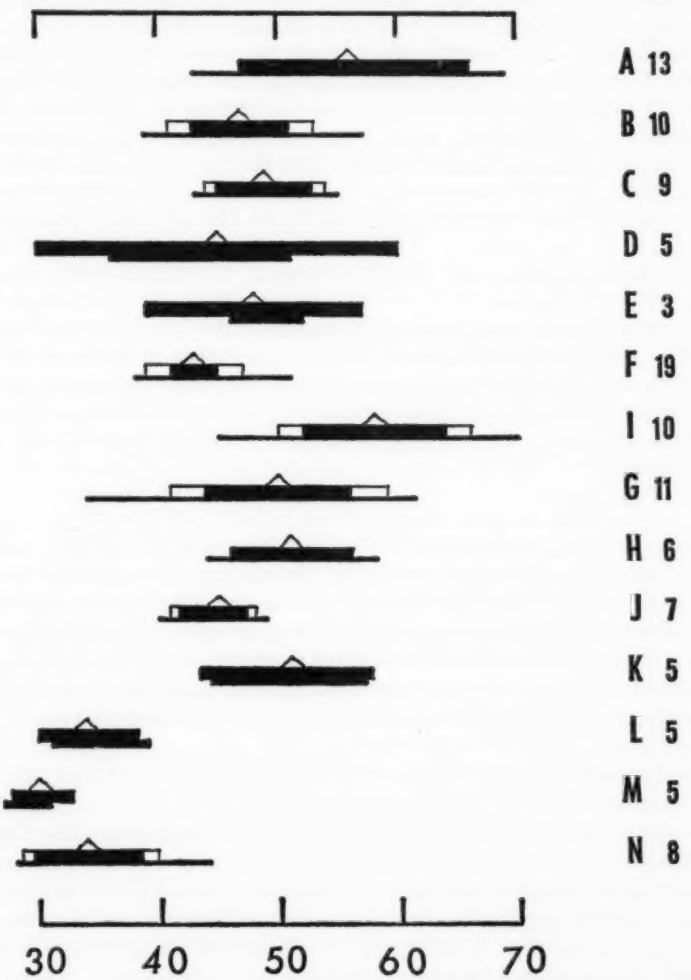

FIG. 2.—Darkness variation in southwestern red squirrels. Scale indicates percentage of black banding of hair in each population. Higher percentages respresent darker populations. Other symbols, letters and numbers as in Fig. 1.

ARIZONA: *Coconino Co.*: 10 mi NW Deerwater Ranch, 9,000 ft, San Francisco Mts., 2 (UA); VT Park, Kaibab Forest, 8,800 ft, 2 (UA); Hutch Mt., 8,500 ft, 25 mi S and 14 mi E Flagstaff, 11. *Apache Co.*: Lukachukai Pass, 8,800 ft, 1 (UA); Springerville, 25 mi S upper West Fork Black River, 2 (UA); 20 mi S Big Lake, 9,000 ft, 1 (UA); West Fork Black River, 3 (UA); 16 mi W and 4 mi S Springerville, 19. *Graham Co.*: Hospital Flat, Mt. Graham, 1 (UA). *Greenlee Co.*: 5 mi S Blue Turnoff, US Highway 66, 1 (UA); 4 mi NE Hannagan Meadows, 9 (UI); 1 mi NNE Hannagan Meadows, 1 (UI).

NEW MEXICO: *San Juan Co.*: Washington Pass, 6 mi E Crystal, Chuska Mts., 5. *Rio Arriba Co.*: 10½ mi E Chama, East Fork Rio Brazos, 10,000 ft, San Juan Mts., 21. *Taos Co.*: Goose Creek, 4 mi S and 2 mi W Red River, 1; Bear Canyon, 6 mi S Red River, 1; 4 mi NE Tres Ritos, 13; 1 mi NW Cowles, 2. *Sandoval Co.*: Fenton Lake, 10 mi N Jemez Springs, Jemez Mts., 8; Bluebird Mesa, Jemez Mts., 7; American Creek, 11 mi E Cuba, Jemez Mts., 1; Rio Las Vacas, near junction with N.M. route 126, Jemez Mts., 3. *Valencia Co.*: Mount Taylor, ½ mi NE La Mosca Peak, 13. *Bernalillo Co.*: Sandia Mountains, 7. *Catron Co.*: Mogollon Mts., 8 mi E Mogollon, 13; Willow Creek, Mogollon Mts., 10 mi E Mogollon, 7. *Socorro Co.*: Beartrap Canyon, San Mateo Mts., 19 mi W and 20 mi S Magdalena, 23. *Torrance Co.*: Red Canyon, Manzano Mts., 4. *Grant Co.*: Iron Canyon, Black Range, 15 mi E and 6 mi N Santa Rita, 10. *Lincoln Co.*: Capitan Mts., 5 mi N and 9 mi E Capitan, 5; White Mts., 4 mi W Alto, 11. *Otero Co.*: 1 mi S Cloudcroft, Sacramento Mts., 5; 4 mi S Cloudcroft, Sacramento Mts., 5; 10 mi S and 1 mi W Cloudcroft, Sacramento Mts., 1.

RESULTS

Before utilizing cranial proportions and dimensions in geographic comparisons, I studied each character to evaluate its relationship to absolute size and age of the animal. These finding are noted among the comments upon each dimension or proportion which follow. In some cases the mean of sample means is given below. This statistic approximates the mean value of the given characteristic for the entire collection of animals. A sample mean which deviates significantly from the mean of means calls attention to aberrancy of the sample in that trait.

Condylobasilar length.—Taken as described by Cockrum (1955: 34). This is a useful index of over-all size in *Tamiasciurus*; head and body length, hind foot length, and most other absolute dimensions except as noted below are positively correlated with condylobasilar length, and hence should not be treated as independent variables. Cranial size is the only cranial feature in which a definite geographic trend is seen in southwestern red squirrels. Animals from the San Juan Mountains are smallest; from this point size increases radially in all southerly directions (Fig. 1).

Zygomatic breadth.—Taken as described by Cockrum (*op. cit.*). This dimension increases more rapidly than does condylobasilar length until the

permanent premolars are in place. After this event, the relative zygomatic breadth (zygomatic breadth/condylobasilar length × 100) does not change significantly. Therefore the relative breadth of adults may be used in geographic comparisons. The sample means for this proportion cluster about 68 per cent. Only two sample means, those from the Sandia and Manzano Mountains, depart from the mean of sample means (67.9%) by two standard deviation units or more (standard deviation of sample means). No geographic trends or groupings may be seen from a study of this characteristic.

Postorbital breadth.—Taken as described by Cockrum (*op. cit.*). This dimension does not change with increasing age or size. Seemingly the postorbital breadth is at its maximum early in life and changes little thereafter. Neither is this feature correlated with over-all skull size. Accordingly, the dimension taken from all individuals in a sample may be used as an independent variable in geographic comparison. This comparison shows no geographic trends. The mean of sample means is 14.7 mm. The Sandia Mountain sample departs most from this mean.

Maxillary toothrow.—The distance between the anterior border of the alveolus of p^4 and the posterior border of the alveolus of m^3. A vestigial p^3, irregularly present in *Tamiasciurus*, does not affect this measurement. Until the permanent fourth premolar is in place the condylobasilar length increases more rapidly than the length of the toothrow. Larger skulls have longer toothrows. Once permanent teeth are in place, the index "maxillary toothrow/condylobasilar length × 100" becomes independent of skull size. Thus this ratio derived from skulls of adults may be used in geographic comparison. The mean of sample means of this statistic is 20.7 per cent. No geographic trends or especially aberrant populations are noted in a study of this feature.

Nasal length.—The distance between a line connecting the anteriormost parts of both nasal bones (frequently in the midline of the skull) and a line connecting the posteriormost points of the nasal bones. This dimension increases with condylobasilar length in such a way that the index "nasal length/condylobasilar length × 100" does not change significantly with age or size. The index is not dependent upon skull size; this feature taken from all animals in a sample may be used as an independently variable characteristic in studies of geographic variation. The mean of sample means of this percentage is 38.3 per cent. No geographic trends are seen and no sample mean deviates significantly from the mean of means.

Tail length.—The standard measure of tail length taken from the fresh, intact animal. All measurements used were taken in the field by me. Tail length was expressed and studied as a percentage of head and body length (caudal index). This index is larger in animals which do not yet have their permanent teeth, suggesting that tail length ceases to increase early or increases at a lesser rate than head and body length. Among animals with all permanent teeth in place, a slight but not significant decrease in the index is seen with increasing head and body length. Thus caudal index of adults may be used for geographic

comparisons. The mean of the sample means of caudal index is 68 per cent. No geographic trends or significant local departures from this figure are revealed.

Color.—Darkness of dorsal coloration was studied as described above. Higher darkness indices indicate darker animals. Breadth, length, and intensity of lateral stripe are positively correlated with this index. The mean of sample means for this feature is 46 per cent. Most means cluster fairly closely about this figure. San Mateo (I, Fig. 2) and San Juan (A) samples depart most in the direction of darkness. The samples from the Capitan, White and Sacramento Mountains (L, M, N) depart markedly as a group in the direction of paleness. No samples intermediate in color between the latter three and others have been seen. This is the only case of such strongly marked geographic variation seen in my material.

The colored bands of the dorsal hairs vary from yellowish to reddish. By assigning a low number to yellowest and a high number to reddest animals, I ranked specimens and studied this feature which seems to vary independently. Animals from the most arid ranges often are reddest. However, the Black and San Mateo ranges are rather dry. Yellowest animals are those from the San Mateo–Black–Mogollon–White group (I, H, G, F, respectively). Reddest animals are from the White Mountains of New Mexico (M).

The tips of the guard hairs of the tail may be either white or buff. In juvenal pelage, buff is frequent. Some populations may have buff-tipped hairs in winter and white-tipped ones in summer. Among adults, buff tips are seen among the animals from the Sacramento–White–Capitan group, from some Sandia and Manzano specimens, and in the one specimen I have seen from the Graham Mountains. Others have whitish-tipped hairs.

DISCUSSION

Among the traits studied in southwestern red squirrels, size, darkness, color of light bands of hairs, and color of tips of tail hairs show notable geographic variation.

Since southern chickarees tend to be larger than northern ones, one is tempted to look for some latitudinally varying environmental feature to account for size variation. Inspection of climatic data and of the places from which the squirrels were taken does not reveal any obvious explanation. While climatic data are rarely available from the montane collection stations, it is likely that, given the same altitude and exposure, growing seasons would be longer at more southern stations. Longer growing seasons might allow for greater abundance of some plant food important to growth of red squirrels. In any event, the possibility exists that size variation in the chickarees is not genetically determined.

Variation in darkness shows a definite pattern. The populations of the Capitan, White, and Sacramento Mountains are significantly lighter in color than all other populations studied except the Chuska sample, which shows

considerable variability. In addition, these three southeastern populations are almost alone in having buffy-tipped tail hairs. Other populations studied consist of darker animals with white-tipped tail hairs. Between these other populations, differences, sometimes significant, in darkness are to be seen, but no population stands out as clearly different from all the rest. Samples from points successively closer to the San Mateo Mountains demonstrate a successive increase in darkness. On the latter mountain range (I) exist the darkest southwestern red squirrels. Yellowness and redness seem to vary independently of darkness, though the darkest population (I) is also the yellowest, and the palest (M) is also the reddest.

The most differentiated populations, in terms of color, seem to be, first, those from the three southeastern ranges (L, M, N) and, second, those from the Mogollon–Black Range–San Mateo (G, H, I) area.

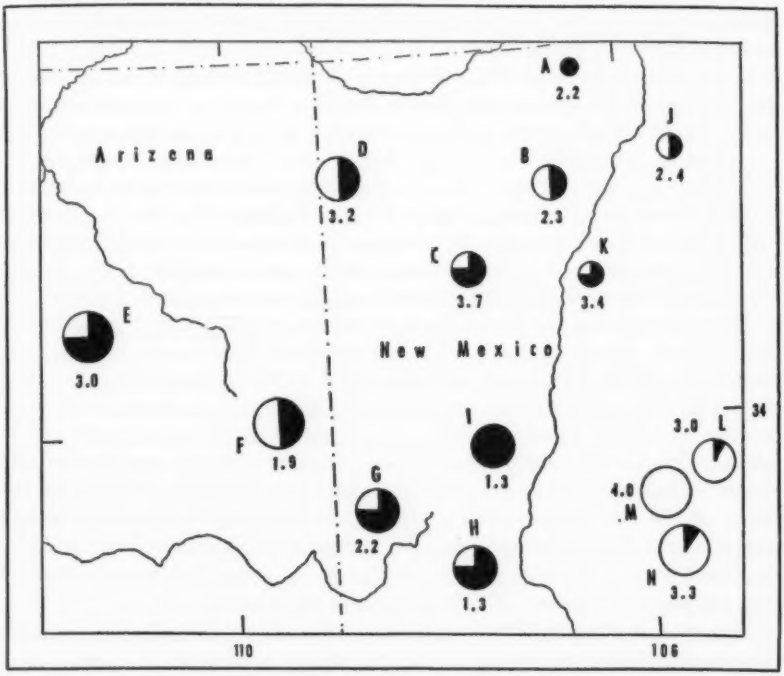

FIG. 3.—Map of western New Mexico and eastern Arizona, showing some stations of occurrence of chickarees and some characteristics of each population. Circle size is proportional to average size of animals; darkness of circle is proportional to average darkness index of sample; number beneath circle represents yellow–red index of sample; higher numbers indicate redder animals. Letters represent mountain ranges as follows: A, San Juan; B, Jemez; C, Mt. Taylor; D, Chuska; E, Hutch; F, White; G, Mogollon; H, Black; I, San Mateo; J, Sangre de Cristo; K, Sandia; L, Capitan; M, White (Sierra Blanca); N, Sacramento.

Two populations show some tendency toward cranial distinctiveness. The skulls of specimens from Mount Taylor (C) may all be distinguished by the possession of nasal bones which are truncate, rather than acute, posteriorly. The skulls of specimens from the Sandias (K) seem to have an unusually small zygomatic breadth.

I am unable to account for color variation in southwestern chickarees by reference to environmental factors. One might expect that darker animals would come from places with darker backgrounds, such as darker soil, or perhaps more shade. However, such a correlation is not evident after having dwelt in and studied all 14 stations from which the specimens came. I am inclined to attribute color variation in southwestern *Tamiasciurus* to random genetic fixation. Such fixation would have the most pronounced effects in places where it had the longest time to act. For reasons outlined below, I think that the populations of *Tamiasciurus* which seem to be most differentiated occupy montane forests which have been longest isolated from other montane forests in the Southwest.

Each montane forest considered here is isolated, by habitat unsuitable for the squirrels, from every other forest. But the degree of isolation varies in each case. All of the more northern stations (A–F, J–K, on the map) while separated by unsuitable red squirrel habitat, are, nonetheless, separated by high plains or plateau country which is known to have supported at least *Pinus ponderosa* in the recent past, to judge from archeological studies. A relatively slight increase in precipitation and decrease in temperature would likely make possible a continuous red squirrel range over the entire area. The more southern stations are connected to northern highlands by narrow upland corridors and are in part bordered by lowlands at present supporting desert grassland or creosote bush desert rather than mixed-grass prairies or some higher plant community. With drying and warming which followed the last southwestern pluvial interval, these southern ranges, peripheral to the main range of *Tamiasciurus*, would have been the first to support boreal communities to some extent isolated from more northern ones. Theoretically, the most formidable barrier to boreal colonies of organisms in the area considered should be the valley of the Rio Grande with its tongue of Chihuahuan desert extending northward nearly to Albuquerque. The red squirrel populations separated by the desert parts of the valley are more sharply differentiated from each other than are any other groups of red squirrels in the Southwest.

Durrant and Hansen (1954), in their studies of Utah chickarees, showed that the peripheral populations of the Pine Valley Mountains of southwestern Utah have become differentiated (as *T. h. dixiensis* Hardy). Similarly, Anderson (1959), in his review of the montane vole, *Microtus montanus*, has revealed marked peripheral differentiation in this species. That this situation is common in western montane mammals and that it is related to past expansion and contraction of the geographic ranges of these animals seems an entirely reasonable assumption.

Red squirrels from New Mexico and Arizona have been referred to four subspecies. *Tamiasciurus h. lychnuchus* (Stone and Rehn) occupies the Capitan, White, and Sacramento Mountains in New Mexico (stations L, M, N). This is a large form characterized by the presence of a reduced black banding on the guard hairs of the dorsum and by buff-tipped guard hairs of the tail. The type came from Forks of Ruidoso Creek, White Mountains, Lincoln Co., New Mexico. The map of the distribution of this form in Hall and Kelson (1959: 400) shows a record of occurrence in the Guadalupe Mountains, New Mexico, taken from Bailey (1931: 80). This record is based on the following statement by Bailey: "In the southern part of the Guadalupe Mountains in 1902 a small tree squirrel was reported as of very rare occurrence, but no trace of it could be found." Davis (1940: 78), in noting the absence of tree squirrels in the Guadalupe Mountains of Texas, commented as follows: "The presence of chipmunks and the complete absence of tree squirrels (*Tamiasciurus*) here (even as fossils), are further evidence that red squirrels extended their range southward after desert conditions had become established in the Southwest. . . . The 'small tree squirrel' to which Bailey refers doubtless is the chipmunk. . . ." My own studies in the Guadalupe Mountains indicate the unlikelihood of the occurrence of red squirrels there. Suitable habitat in the Guadalupes for these animals does not seem to exist. *Tamiasciurus h. mogollonensis* (Mearns), based on animals from Quaking Asp Settlement, between Stoneman Lake and Mormon Lake, near summit of Mogollon Mountains, Coconino County, Arizona, is characterized by large size and strong rufous suffusion of upperparts (Allen, 1898: 292–294). At present the range ascribed to this form includes Arizona, except the Graham Mountains, and New Mexico except for the area occupied by *T. h. lychnuchus* and the extreme northern San Juan Mountains. Formerly, animals from the Sangre de Cristo Range were recognized as *T. fremonti neomexicanus* (J. A. Allen). This form was characterized as being small (like *T. h. fremonti*) but rufescent (like *T. h. mogollonensis*). Bailey (1931: 75–76) regarded *neomexicanus* as inseparable from *mogollonensis*. One specimen from the northern San Juan Mountains was assigned by both Allen (1898: 294) and Bailey (1931: 74–75) to the Coloradan form *T. h. fremonti* (Audubon and Bachman).

The isolated population of squirrels from the Graham Mountains, Arizona, has been named *T. h. grahamensis* (Allen). This form supposedly differs from *T. h. mogollonensis* in having more yellowish, less rufescent coloration and the central area of tail ochraceous above and nearly white below. Seemingly few specimens of this form are extant. Allen (1898: 293) listed three specimens. Hoffmeister (1956: 273–274) examined but three specimens and regarded the animals as not abundant in the Grahams. The one specimen I have seen agrees with Allen's description.

Findings reported here do not, in my judgment, call for revisions of the nomenclatorial arrangements outlined above. Using criteria employed by earlier workers, naming of at least two additional subspecies (from San Mateo

Mountains and Mount Taylor) could easily be justified and, it could be argued, should be done for the sake of consistency. To my mind the immediate object of studies of geographic variation is in revealing kind and degree of variation. This should be done in the most complete and meaningful way possible. In the present case, subspecific assignments would and do reveal some aspects of variation while obscuring many others.

CONCLUSIONS

1. Southwestern chickarees show little geographic variation other than in color and size.
2. Color of southwestern chickarees varies in darkness, in degree of redness or yellowness, and in color of tips of tail hairs. These attributes seem to vary independently.
3. Most southwestern chickarees are approximately the same in degree of darkness. Exceptions are the markedly dark animals inhabiting the San Mateo Mountains and the markedly pale ones inhabiting the mountains of the Sacramento complex.
4. Chickarees from the San Juan Mountains are small; progressing radially in southern directions, size increases. Longer growing seasons on southern ranges might account for large southern animals.
5. Animals most different from norms for southwestern chickarees are found on southern mountains peripheral to the range of the species. It is suggested that this differentiation may be a result of random genetic fixation. Reasons for the more pronounced effect of this phenomenon in these places are offered.

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MOVEMENTS OF HARVEST MICE TAGGED WITH GOLD-198

By Stephen V. Kaye[1]

Abstract: Four eastern harvest mice, *Reithrodontomys h. humulis*, were tagged with gold-198 wires and traced in the field by the use of a Geiger counter. This method is superior to live-trapping because multiple-handling of animals is eliminated, animal movements are unrestricted, and more information about an individual can be obtained in a shorter length of time.

When mice were released from live-traps their movements during the following several hours were suggestive of meandering, indicating that they may have been confused, frightened, or hungry from overnight trap confinement. Small globular-shaped grass nests located in or under the herbaceous layer of vegetation were used as den sites. The nests were situated on the periphery of the range and varied from 2 to 4 per animal. Harvest mice movements were mostly limited to night, but during winter occasional short diurnal movements from nests were recorded.

Certain areas within the range of each tagged mouse were avoided completely. The behavior and movements of the tagged mice presented a complex picture of spatial relationships. Calculation of range size was not undertaken because presently used methods and concepts were difficult to apply to the data.

Although artificially produced radioisotopes have been available to mammalogists in this country for over 14 years, very little work has been published utilizing them in studies of small-mammal ecology. The classical work in this field was done in England by Godfrey (1953, 1954), who studied the ecology and life history of wild *Microtus agrestis* tagged with leg rings containing a cobalt-60 source. In a later work she attached metal rings containing cobalt-60 to the tails of European moles, *Talpa europaea*, and studied their subterranean movements (Godfrey, 1955). Work in this country by Miller (1957) utilized a somewhat different approach. He detected radioactive urine and fecal pellets deposited on aluminum dropping boards by a single *Microtus pennsylvanicus* injected with 200 μc of phosphorus-32. This method cannot be judged to be wholly satisfactory because traces of radioactivity are washed off the dropping boards during times of rain. Successful use of radioactive leg bands containing antimony-124 has been reported by Punt and van Nieuwenhoven (1957), who traced hibernating bats. Gifford and Griffin (1960) used a similarly designed leg band containing iodine-131 to study the homing and migratory behavior of bats.

The advantages derived from the use of radioisotope tags are many. The elimination of multiple animal handlings and trappings is a major feature of this technique. Animals tagged with radioisotopes are not restricted in their movements as are animals which are trapped, and much more information about an individual animal can be gained in a shorter length of time. The data obtained by this method are applicable to studies of home range, territoriality, dispersal, migrations, life history, and other aspects of mammal behavior which are studied. Another important advantage is that radioisotope

[1] Recipient of an honorarium in 1960 for this paper.

tagging studies can be carried out under all weather conditions and at any time of day or night. Cost of radioisotopes is surprisingly low.

One disadvantage is that tagged individuals in the same area cannot be distinguished easily. Therefore, only a single individual in an area should be tagged at one time. Another approach would be to tag a large number of animals or a whole population, and study it in such a way that it would only be necessary to identify an animal with the group and not on an individual level. A second minor disadvantage is that a study area is required which is reasonably safe for isotope usage. Many study areas now in use for trapping will easily meet this requirement, whereas others will be unfavorable because of their proximity to humans or domesticated animals.

The major objective of this investigation was to make an intensive study of movements and spatial relationships of eastern harvest mice by tracing, in their natural habitat, individuals tagged with radioactive gold-198. This radioisotope is suitable for tagging because it has the safety of a 2.7-day half-life as well as an adequate gamma energy of 0.41 mev. The distance of detection of an isotopic tag is directly proportional to its gamma energy and activity. When used in activities of less than 5 mc the short half-life renders the activity of a lost tag negligible in less than one month. Of course this condition will also limit the useful life of the tag. Eastern harvest mice were traced for as long as 10 days before radioactive decay necessitated recapture to retrieve the gold wires. Two mice were tagged at different times during the summer of 1958, one was tagged in the winter of 1958–59, and a fourth was tagged in the spring of 1959.

PROCEDURE

The procedure used in this study to tag and follow eastern harvest mice has been reported fully elsewhere (Kaye, 1960). The tags were small gold-198 wires which were inserted subcutaneously in the lower abdominal region of wild live-trapped mice. The animals were released at the point of capture and their subsequent movements were traced with a portable Geiger counter (RCA model WF-12A). Each time a tagged mouse was detected, a wire marker was inserted into the ground at the point of detection.

DESCRIPTION OF ISOTOPE STUDY PLOT

The study plot chosen for isotope tagging is located on the North Carolina State College dairy farm at Raleigh. Vegetation in this plot was uniformly thick fescue (*Festuca* spp.) except for a few isolated groups of horse nettle (*Solanum carolinense*) and some sparse clumps of broomsedge (*Andropogon* spp.). Good drainage is afforded most parts of the field by a moderate slope to the west.

A hog-wire fence completely encloses this rectangular, 2.1-acre plot which is not accessible to cattle. A dirt road borders the plot on all sides except the east, where a field similar to the study plot is located. The far side of the dirt road, on the north and south sides of the plot, is bounded by a wire fence

which separates pastureland from the ungrazed study area. The far side of the dirt road on the south side of the plot runs parallel to a wire fence which delimits an alfalfa field.

HARVEST MOUSE MOVEMENTS

In the following accounts, for uniformity and saving of space, times are noted by the 24-hour clock system; i.e., 0815 = 8:15 AM, 1200 = noon, 1627 = 4:27 PM, etc.

Mouse No. 1, Summer 1958.—The first mouse to be tagged was a pregnant female which was captured, tagged with a 0.7 mc source, released on the morning of 27 August, and relocated 38 times at various intervals over a period of seven days. During this period the weather was mild, with no rain; average minimum and maximum air temperatures were 64° and 82°F.

The location numbers referred to in the discussion of movements of this mouse are shown in Fig. 1. After release at 1050, the tagged mouse moved around in a small area (locations 1–5), showing no pattern of definite orientation. Possibly the mouse was feeding, for it might have been captured early

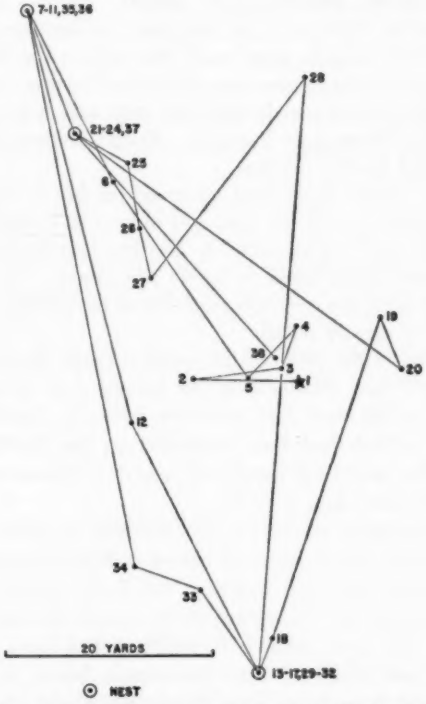

FIG. 1.—Movements of mouse No. 1, tagged with Au^{198}, between 27 August and 1 September 1958. Point of initial release marked by star.

the previous evening and been without food and water for some time. Thus, movements 1 through 5 may represent a search for food. When the mouse was located for the sixth time, it was found more than 25 yards from location 5 but was not moving. No further attempts were made on the first day to locate the mouse.

At 1115 of the second day, the mouse was located in a grass nest in which it remained until at least 1600. The nest was not visible until the thick grass covering it had been parted, revealing its position at the base of a clump of fescue. This nest was checked with the Geiger counter at 1800, but the mouse had already left and was not located until 1915 at location 12, moving rapidly in a direction away from the nest.

On the third day the mouse occupied a different nest (locations 13–17) at the opposite end of the plot. When this nest was checked at 1830, it was still in use, but by 1905 it had been vacated, and the mouse was detected moving slowly at location 18. Fifty minutes later it had reached location 19, and probably foraged in the general area for some time, since it was located only a few yards away (location 20) at 2300. Further searching from 2330 until 0045 did not disclose the location of the mouse.

The afternoon of the following day was spent in another nest, the third to be used in three days. Checks were made throughout the day (locations 21–24), during which time the mouse was always in the nest. When location 24 was determined, the mouse was leaving the nest and was found 35 minutes later at location 25. Three more locations (26–28) were made before searching was discontinued for the evening.

Part of day 5 was spent in the nest occupied on day 3. Sometime between 1800 and 1850, the mouse left the nest and moved to location 33. At 1910 it had moved about 6 yards to location 34. Further searching in its established range from 1935 until 2045 failed to locate the mouse. The term "range" is used in accordance with the concepts established by Godfrey (1954) and will be discussed later in greater detail.

When examination of the plot was resumed at 0900, the tagged mouse was located in the nest it had occupied on the second day. Location 36 at 1030 disclosed it again in this nest, but sometime between that time and 1600 it moved to the nest which had been occupied on the fourth day (locations 21–24). This was the only time the mouse was detected occupying more than one nest during the same day.

Due to radioactive decay of the tag, the distance of detection by 1800 was down to about 1½ feet. Traps were set before dark in the area that the mouse had been frequenting. The next morning, day 7, the mouse was taken alive in a live-trap at location 38. Dissection of the sacrificed animal disclosed the gold intact and in the exact location in which it had been implanted. Four full-term embryos were removed from the uterine horns. It is believed that these embryos would have been born during the night, since their average weight was 1.3 grams, which compares favorably with an average weight of

1.23 grams at birth for 24 young born in the author's laboratory colony of harvest mice from the same area.

The repeated failure to make contact with the mouse at night can probably be attributed to the fact that the mouse was crossing behind the investigator and into the area which had just been searched. The animals are constantly on the move at night, whereas during the day they are more or less sedentary.

Mouse No. 2, Summer 1958.—A 0.7 mc source was used to tag the second mouse, a subadult male. During the seven days this harvest mouse was followed, it was located 29 times at 14 different positions, as illustrated in Fig. 2.

The average daily minimum and maximum temperatures of 59° and 78°F recorded during the period this mouse was tagged are slightly lower than those recorded for the first summer tagging. Weather conditions remained clear and without rain during the entire period, except for a trace of rain on the third day.

Behavior of the mouse after release on 10 September was much the same as was recorded for the first tagged mouse (Fig. 1, locations 1–5). Diurnal hours were spent moving about slowly or sitting (locations 1–4), no nest being utilized. Locations 5 and 6, at 2123 and 2207, indicate the mouse had moved about 25 yards from the area occupied during the day.

Locations 7–9 of the second day revealed the mouse in a typical grass nest. The third day the mouse was located twice, locations 10 and 11, in another nest. At 1350 contact was made with the mouse at a position about 2 yards from the nest. Further detections were not attempted during the afternoon. A concentrated effort of one and one-half hours at night failed to reveal the location of the mouse, even though the entire study plot was covered.

At 0900 of the fourth day, the mouse was detected occupying a third nest, apparently remaining in it until the late afternoon or early evening. The mouse is believed to have left the nest around 1830, since it was detected at location 17 at 1840, only 8 yards from the nest. At 1905 it was sitting at location 18 (location 5 of the first day). Examination of the habitat disclosed the skeleton of a mourning dove, *Zenaidura macroura*, 14 inches from where the

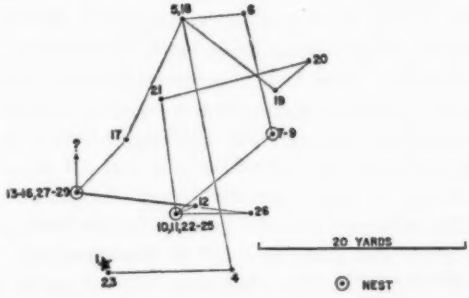

FIG. 2.—Movements of mouse No. 2 from 10 to 16 September 1958.

mouse had been detected on the two occasions. None of the bones exhibited evidence of rodent gnawing; however, a few were missing.

The following morning, the fifth day after release, the mouse was caught alive in one of several live-traps which were allowed to remain set during the time the mouse had been tagged. After release, the mouse was detected moving around at location 20. Later in the evening, it was detected about 15 yards away at location 21. Additional searching in the animal's normal range from 2330 until midnight was concluded without locating the mouse.

The nest which was occupied on the third day was again used on the sixth day (locations 22–25). By 1820 the mouse had left the nest to resume its usual evening foraging activities. Ten minutes after this location was made, a search in the same general area was conducted to no avail. A search was then initiated which covered the entire plot and a small area around it but was terminated two hours later without locating the mouse. Evidently the mouse was still close by but was missed in the search, because it was located the next morning (day 7) in the nest it had occupied on the fourth day. This nest remained occupied until the last reading was taken at 1820. At this time, the mouse was slowly leaving the nest in the direction of the arrow in Fig. 2. No further searching was done that evening; however, at 0445 the next morning searching was resumed and continued until 0725 without success. Although searching was continued that evening and at various intervals for the next four days, the mouse was not relocated. It can be assumed that the mouse disappeared between 1820 of the seventh day and the early morning of the following day.

Two hypotheses may be advanced to explain the disappearance of the mouse. First is the hypothesis of emigration. This harvest mouse, a subadult, may have been occupying a maternal range which it vacated the night that it was missed. Frank (1957) demonstrated this behavior for European microtines: "Recently we found that in spring and summer the young males without exception disappear from their mother's territory and its surroundings after becoming mature. . . ." Possibly this behavior is also true for *Reithrodontomys h. humulis*.

The alternate hypothesis is that the mouse was taken during the night by a mobile predator. While the author was searching for the first mouse on the evening of 31 August, a great horned owl (*Bubo virginianus*) glided over the study plot, coming within about 15 feet of the investigator. This owl had been heard on numerous occasions calling from a small woodland on the college farm but had never before been sighted. Two nights before the disappearance of the mouse, the owl had been heard but not seen. It seems quite possible that the owl hunted in the study plot and caught the mouse after the author left the area at 1830. Although the owl seems to be the most obvious predator, the mouse could have been taken by a cat or other predatory animal.

Mouse No. 3, Winter 1959.—An adult male harvest mouse in nonbreeding condition was chosen for the third tagging. This mouse was tagged with a

4.5 mc gold-198 source on the morning of 27 January and retrieved nine days later. Four different nests were utilized during this tagging experiment, and the mouse was located 62 times at 39 different positions (Fig. 3). Lower temperatures (31.5°F average minimum and 48.0°F average maximum) seemed to have a significant effect on the behavior of the mouse.

The detection distance for this source was almost 20 feet from the Geiger tube, considerably farther than the detection distance of the 0.7 mc sources used for the two summer taggings. The greater detection range resulted in better contact success, particularly when the mouse was moving; however, difficulty was experienced at very close ranges because the capacity of the Geiger counter was exceeded.

A considerable amount of movement was recorded during the first day the mouse was tagged (locations 1–5). As in the case of the two summer taggings, no nest was used during the first day.

A few live-traps had been left set in the plot, and at 1110 of the second day the mouse was discovered in one of these traps and was immediately released. The remainder of the traps left in the plot were sprung.

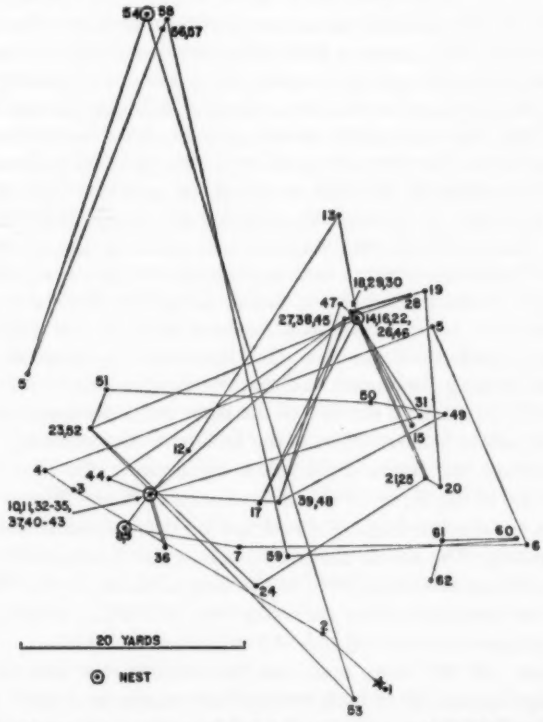

FIG. 3.—Movements of mouse No. 3 from 27 January to 5 February 1959.

At 1145 the mouse was sighted moving through the grass at location 7, and at 1245 it was occupying a grass nest (location 8). At 1500 the mouse was still in the nest, but at 1630 it was detected occupying a different nest, the second to be utilized that day. Between 1815 and 1845, it vacated the nest and was found about 5 yards away at location 12. A change from its expected behavior was encountered when this harvest mouse was detected in a nest at 2100 (location 14). Neither of the mice previously tagged had been detected in a nest after dark. This nest was the third to be occupied that day. When location 15 was made slightly more than an hour later, the mouse was no longer in the nest but was located sitting about 10 yards away.

A check at 0900 the following day revealed the mouse to be in the third nest occupied on the previous evening. During the afternoon and early evening, the mouse was not in the nest (locations 17–21). At 2055, however, the mouse was back in the nest which it occupied during the morning. This observation almost coincides with its movements of the previous evening when it was located in the same nest at 2100. On both evenings the length of time the mouse stayed in the nest was short, after which it resumed its foraging activities.

Day 4 was one of considerable activity and little nesting. The first attempt to locate the mouse was made at 0500. Fifteen minutes later it was discovered at location 24, probably resting or eating since it was not moving. By 0640 it had moved almost 20 yards to the exact place it had been located the previous evening at 1920. An examination of this spot disclosed a small nonvegetated clearing 9 inches in diameter obscured by a canopy of thick fescue. At 0920 the mouse was resting in the nest occupied the previous day; however, five subsequent locations, 27 through 31, revealed the mouse near the same nest. The mouse was recorded occupying the nest used on the afternoon of the second day. No further attempt was made to locate the mouse until 0900 the next morning, at which time it was found occupying the same nest. It remained in this nest at least until midafternoon when it was detected at 1630 sitting about 5 yards from the nest. One hour later, it returned to the same nest. By late evening the mouse had traversed a distance of 35 yards, when it was located 2 yards from the last of the three nests occupied on the second day. This detection, location 38, was the last made that evening.

When searching was resumed the following morning, the mouse was not to be found in any of the three nests but was located sitting about 4 inches from the rear of a sprung live-trap. It could not be determined if the mouse was feeding or resting. The mouse did not remain at this location very long, since it was located from 1050 until 2045 in the nest used on day 5. The last time the mouse was detected on the sixth day was at 2145, at which time it was discovered at location 44 sitting only 4 yards from the nest.

Six locations (45–50) were made on the seventh day between 0730 and 2230, but only location 46 at 0900 revealed the mouse in a nest. Location 48 at 1330 disclosed the mouse at an unexpected position, sitting next to a sprung

live-trap, the same trap by which it had sat the previous day. On both occasions it was found about 4 inches from the rear of the trap.

Freezing rain on the eighth day blanketed the study plot with a crust of ice. The heaviness of the ice weighted down the grass, pressing it close to the ground. An attempt to locate the mouse in its usual haunts between 1130 and noon met with failure; it was also not to be found in any of the three nests. Searching was not resumed until 1800. At 1815 the mouse was found at location 51, moving rapidly across the plot to location 52, at which point it was detected sitting 45 minutes later. The last attempt to locate the mouse that evening was successful when it was detected at 2245, moving slowly only a few yards from the point of original capture.

The rain which started on the morning of day 8 continued on into the following day and by the time it stopped at 2200, the total was 1.6 inches for the two days. Temperature remained near freezing most of the day, falling as low as 29°F in the morning and rising as high as 40°F in the afternoon. The field was very wet and in some places the puddles of water which had accumulated were partially frozen. Searching was begun in the early morning, but the mouse could not be found in its established range. Finally, at 1155, the mouse was found in a new nest, the fourth to be occupied. This nest was located on the remnant of an old terrace. The nest location was about 40 yards from the established range of the animal. The height of the mound was about 6 inches and afforded good drainage. Probably these physical characteristics influenced the mouse to choose the location as a nest site after its other nests had become inundated. The only other contact with the mouse during the ninth day was made at 2200, location 55, which disclosed a movement of about 35 yards from the nest.

On the tenth and last day, 1.1 inches of rain fell. A search in the rain resulted in the detection on three occasions of the mouse near but never in the fourth nest (locations 56–58). While many daylight hours were probably spent in the nest, the times the mouse was located did not coincide with these occupancies. Locations 59 through 61 were made after 1800, well within the limits of the previously established range of the mouse. At 2130, the mouse was being traced when it was seen moving slowly over the top of matted fescue. A quick grab resulted in catching the mouse by the tail. It was transported to the laboratory where the gold-198 wire was recovered.

Mouse No. 4, Spring 1959.—In the late afternoon of 15 April, 77 live-traps were set in the study plot. At 2300, two catches had been made. One was an adult male harvest mouse, the other an adult female. Since only one female had been previously tagged, as compared with two males, the female was selected for tagging. The well-developed nipples revealed that she had recently nursed a litter. Lactation was not functional at this time and she did not appear to be pregnant as determined by palpation.

A 2.9 mc source was implanted under the skin of this mouse before her release at the point of capture at 2355. During the next 10 days, 50 locations

were made at 19 different positions (Fig. 4). The averages of the daily extreme temperature ranges during this period were 48.9° average minimum and 71.7°F average maximum.

The morning following release, the mouse was detected in a grass nest from 0920 until 1810 (locations 2–5). Locations 6–8, which were made in the evening, revealed the mouse to be circling in a small area about 15 yards from the nest.

Between the hours of 0800 and 1810 of the third and fourth days, the mouse was always found in the same nest it had used on the second day. More than one hour of searching was spent on each evening of days 2 through 4, but no trace of the mouse was found. A heavy downpour started about 1530 on the fourth day and continued into the evening, flooding the poorly drained sections of the plot.

The first location on the fifth day was made at 1230, at which time the mouse was occupying a different nest (location 20) only 3 yards from the one used on the previous three days. The bottom of the first nest was partially covered with water. The new nest was on the side of a small mound of soil surrounding a clump of fescue. This location provided a safety factor of about 2 inches in elevation over the surrounding area, enough to prevent the nest from being flooded. The mouse was detected in the nest twice more during subsequent checks in the afternoon. Further searches in the evening located the tagged mouse (locations 23–26), even though it was not in the nest. At location 25, the farthest location from a nest, the mouse was sighted as it made its way through a sparsely vegetated patch. Both locations 23 and 26 were made at the same position, an area of thick fescue.

On the sixth day the mouse was detected three times in the nest of the previous day. Efforts to locate her from 1745 until 1835 were of no avail.

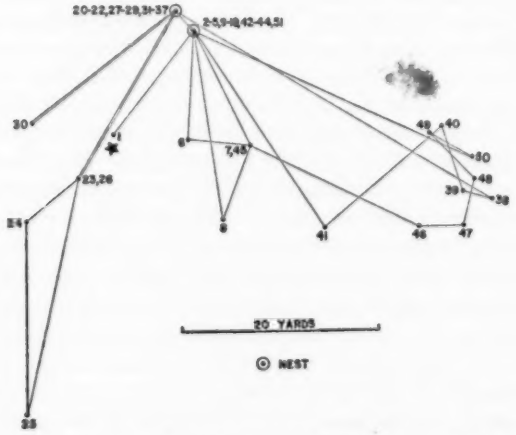

FIG. 4.—Movements of mouse No. 4 from 15 to 25 April 1959.

One trap was overlooked when I attempted to spring all traps on the study plot before the tagged mouse was released, for she was found alive in this trap at 0845 on the seventh day, and was released unharmed at the point of capture (location 30). Subsequent locations during that and the following day resulted in finding the mouse in the second grass nest. Attempts to locate the mouse between 1500 and 1600 of both days failed, for by that time the mouse had left the nest. A careful search after dark was unsuccessful in locating the mouse.

On the ninth day, the mouse was absent from the nest at 1615, after having been located there twice during the morning. During that evening, the mouse was located at position 38 in the alfalfa field which adjoined the plot on the south side. Location 7 was barely within the southern boundary of the plot, being 2 yards from the fence, while location 38 was out of the study plot 21 yards south of the fence. After 30 minutes the mouse was still in the alfalfa field (location 39) and had moved only 4 yards from location 38. Later searching from 2230 to 2330 was unsuccessful.

The mouse was again detected in the alfalfa field twice the next morning. Location 42 made at 1445 disclosed that the mouse was once again inhabiting the nest it had used on days 2, 3 and 4. The puddle which had surrounded this nest had dried, making the nest suitable for occupancy. To determine the exact time the mouse left the nest and returned to the alfalfa field, the author stationed himself close to the nest at 1455. At 1610 the mouse left the nest and started in the general direction of the alfalfa field. At 1612 it was detected at location 45, the exact position of location 7. By 1630 the mouse had moved well within the part of the alfalfa field it had been frequenting previously. Several additional locations were made there. During one of these locations, the mouse was sighted as it sat on its hind quarters and ate a seed. Other seed, secured from the ground with its mouth, were transferred to its cupped forepaws for holding. Before moving off, the mouse stood on its hind legs and nibbled a small cluster of buds from a chickweed plant (*Stellaria* sp.). The mouse then moved about 4 feet, from which point it continued its activities obscured from sight. The elapsed time of the visual observation was about 1½ minutes. The last location of the evening, at 2350, disclosed the harvest mouse still in the alfalfa field.

The next morning the mouse was back in the nest. Its capture brought an end to the study. Subsequent examination of the alfalfa field made it apparent that the mouse probably fed there on the seeds or dried clover plants which had been crowded out by the fast-growing alfalfa. These tiny seeds were abundant on the ground at the spot where the mouse had been feeding. Captive harvest mice of the laboratory population were very fond of clover seeds and cracked open the hulls with great skill.

DESCRIPTION OF NESTS

A total of 12 grass nests were discovered as a result of tracing four harvest mice tagged with radioactive gold. The two mice marked during the summer

occupied three nests each; the mouse tagged during the winter was located in four different nests; and, the one tagged during the spring was found in only two nests.

A typical globular nest is shown in Plate I. Two nests were built in the center of large fescue clumps. The other nests were built on the ground, in each case close to the base of a fescue bunch. The proximity of the large clumps of fescue resulted in the nests being hidden from view in almost every case.

The nests used by the mice during the three seasons of the year were all constructed of fescue. Winter nests were considerably larger than either the spring or the summer nests. The winter nests ranged in size from 3 to 4½ inches in diameter and in height from 1¾ to 2¾ inches. The spring and summer measurements ranged from 2⅛ to 2¾ inches in diameter and from 1 to 2 inches in height. All of the nests contained a single small cavity, apparently large enough to contain only one mouse.

Each nest usually had a small grass tunnel in its side which was used both for entrance and for exit. Two nests had no visible opening. All nests were carefully examined for food caches, but none was found.

Eight of the 12 nests were built in depressions in the soil which were from ¼ to 1 inch deep. Each of these depressions was filled with fescue padding to the level of the soil surface. The diameter of the depression in each case was the same as the nest constructed on top. The depressions were apparently dug by the mice, for these excavations were similar in size, location and construction. Their function when filled with grass must be one of insulaton and padding.

Each of the winter nests contained a few tiny pieces of cotton, obviously pilfered from the live-traps. None of the cotton was found lining the nest cavity, but was always incorporated into the outside portion of the nest wall.

PLATE I.

LEFT: Typical harvest mouse nest. Vegetation has been parted to reveal concealed nest. Note size compared to book of matches. RIGHT: Harvest mouse nest constructed in center of abandoned cotton rat nest. Coarser and darker stems are of cotton rat origin, finer light-colored grass in center was woven in by harvest mouse.

Also, one nest contained a contour feather from a meadowlark (*Sturnella magna*).

One harvest mouse nest was constructed in the center of an old caved-in cotton rat nest (Plate I). The coarseness of the material used in the old nest as well as its very large size (8 inches in diameter) is characteristic of those built by *Sigmodon* in this area.

DISCUSSION

After each of the four tagged mice had been removed from the study plot, the microhabitat at each marked location was inspected and the observations recorded. Only a few small mammal runs were found. Some of these were abandoned cotton rat runs, while others were mouse-sized and poorly defined. These findings suggest that the routes of movement of this species are not through an established runway network of their own. It is hard to ascertain whether or not the mouse-sized runs were those of harvest mice; none of the runs was recorded as being used more than once by an individual mouse.

From the recorded times of activity, it is concluded that *R. humulis* is essentially a nocturnal animal. During the day it can usually be found in a small grass nest located on the surface of the ground. Some variation from this activity pattern was noted for the mouse tagged during the winter; Fig. 3 discloses many daytime locations close to the nests, a change from the behavioral pattern of movements observed for the other tagged mice. During winter it is probably necessary to increase food intake to maintain the high rate of metabolism characteristic of this tiny species (Redmond and Layne, 1958). The observed winter diurnal activities may very well be food-gathering excursions.

Movements of mice up to several hours after release from live-traps are suggestive of meandering, which indicates that the animals may have been confused, frightened or hungry. Containment within the trap, handling, and lack of sufficient food and water are possibly responsible for this behavior. A behavior pattern was not noted for the mouse tagged during the spring because 10 hours had passed between the time of release and first relocation (Fig. 4). Indeed, these movements show that live-trapping induces abnormal behavioral responses in harvest mice after release. The extent to which this is also true for other small mammals is a subject which merits future investigation.

The spatial distribution of nests shown in Figs. 1–4 clearly demonstrates that the nests are not located in the center of the animal's range, but that they are actually located on the periphery. Associated with each nest is usually a group of locations which represent movements from these particular nests more than from others. These groups of locations are here designated as "home areas" and are defined as the areas associated with home sites, i.e., dens, nests, burrows, etc. The "home range" (Burt, 1943) of an animal may include one or more "home areas." In the case of harvest mice, each range contains from two to four home areas (Figs. 1–4). This type of behavior has been described for the beach mouse, *Peromyscus polionotus*, by Blair (1951), who

found that several different homesites were utilized with the activity shifting from one to another. Movements do not occur in all directions from the nest but in most cases tend to be confined to an arc of less than 180°. The home area, therefore, has the nest at one end and most of the activities at a point or area away from the nest. The locations on the extreme right of Fig. 4 are farther removed from the nest than the groups in Figs. 1–3, resulting in an elongated home area. The home areas in the above figures are obvious, and by visual inspection can be associated with particular nests.

Very few locations were made in the spaces midway between home areas or nests, which are generally considered by many to be the centers of greatest activity, but Figs. 1–4 show that all parts of the range are not used to the same degree because some parts are apparently avoided completely. Under these conditions, the calculation of range size becomes a highly complicated and involved procedure, if not an invalid one when not expressed with generous extremes. The problem lies in classifying points such as location 28 in Fig. 1, location 55 in Fig. 3, location 25 in Fig. 4, etc. The analysis of data from live-trapping and even from radioactive tagging is dependent upon interpretation. Because of the complexity of movements in Figs. 1–4, calculation of range size would be an undertaking of questionable value.

The movements of almost all other small mammal species can be studied by the radioisotope tagging method. The findings of the present investigation emphasize the need for additional radioisotope tagging studies. Spatial behavior data derived from such studies will help to answer some of the "home range questions" which heretofore have mostly been speculations based upon objectionable live-trapping techniques.

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BREEDING PERIODS OF THE ORD KANGAROO RAT

By C. Y. McCULLOCH AND J. M. INGLIS

ABSTRACT: During eight intermittent years for which records were available, *Dipodomys ordi richardsoni* seldom bred from April to July. Breeding usually began in August or September and ended in March. Rate of reproduction was associated with precipitation, food supply and population densities of kangaroo rats and other rodents.

Following the 1956 drought, few females became receptive, few young were born, and the population declined. After the favorable growing season of 1957, most females in the sparse population became pregnant within the first two months of the breeding season. Most bred at least twice during that season, and young females born early produced litters before the season ended. In 1958, another year of abundant rainfall and plant growth, the population was dense and few females appeared gravid prior to mid-November. Following a moderately productive 1955 growing season, the population was sparse and reproductive activity was intensive from August to at least the following February. Young born early reproduced later the same season, but there was little indication of second litters produced by old females.

This report summarizes evidence of breeding in kangaroo rats, *Dipodomys ordi richardsoni*, on the sand sagebrush grasslands which occupy sandy soils of the Texas panhandle and western Oklahoma. In that part of the southern Great Plains, the season of reproduction of the kangaroo rat apparently differs from that of other subspecies of *D. ordi*. In central Utah, Duke (1944) reported that *D. ordi* bred from January to March and in September and October. His observations were limited to 35 specimens. Duke also noted communications from W. B. Davis, who found *D. ordi* pregnant in May and June in Idaho and Nevada. Jollie (1955) stated that *D. ordi* in Utah was seasonally polyestrous from February to July. The data of Johnston (1956) indicated that Ord kangaroo rats in southern New Mexico bred from February

to June. In contrast, all records known to us from western Oklahoma and the eastern part of the Texas panhandle show that Ord kangaroo rats were reproductively active in all months from August to March, but only rarely so from April to July.

Data were collected by Inglis during the period from November 1954 to June 1957 in Hemphill County, Texas, 7 miles east of Canadian, on the Gene Howe Wildlife Management Area. Observations by McCulloch were made from August 1956 to November 1958 in Harper and Woodward Counties, Oklahoma, within 5 miles of the town of Fort Supply, on and near the Southern Plains Experimental Range. The Texas and Oklahoma study areas were 65 miles apart.

Kangaroo rats taken in the field were examined during 38 of the calendar months (Tables 2 and 3) of the four-year period spanned by these two studies. When possible, reproductive conditions of females were determined

TABLE 1.—*Observations on breeding conditions of kangaroo rats, prior to the studies of 1954–1958*

Period	Observation	Reference
13 Nov. 1938	Saw copulation of captive kangaroo rats.	Allan, 1944.
11–16 Sept. 1940	Trapped no "breeding females," no rats of immature size.	A. H. Trowbridge, 1941 MS.
22 Nov.–28 Dec. 1940	Took "only a few very young."	" "
20 Dec. 1940	30% of females pregnant.	" "
12–19 June 1941	Took adults only; none in breeding condition; population sparse.	F. B. McMurry, 1942 MS.
21 Nov.–19 Dec. 1941	50% of catch was "juveniles and subadults"; 30% of females pregnant; population had increased "markedly."	A. H. Trowbridge, 1942 MS.
22 May–6 June 1942	None pregnant; fewer than 1% of females showed signs of reproductive activity.	F. B. McMurry, 1943 MS.
11–21 Dec. 1942	6% of females pregnant; average 2.33 embryos per gravid female.	" , 1947 MS.
30 Oct.–20 Dec. 1949	23–31% of catch in total-length class typical of immature rats (<246 mm).	W. J. Frank, 1950 MS.
15–20 Dec. 1949	At least ½ of females showed signs of sexual activity; about ¼ were pregnant.	" "

TABLE 2.—*Breeding periodicity suggested by reproductive conditions of adult female kangaroo rats, Hemphill County, Texas*

Trapping period	Dead-trapped				Live-trapped	
	No. examined	% pregnant	% lactating	No. embryos per pregnant female	No. examined	% with vulva swollen
Nov. 1954	11	18	18	3.00	–	–
March 1955	9	0	11		–	–
May 1955	9	0	0		–	–
June 1955	10	0	0		–	–
Aug. 1955	3	33	0	3.00	57	7
Sept. 1955	4	50	50	3.50	31	6
Nov. 1955	14	21	36	3.00	39	26
Dec. 1955	–	–	–		37	38
Jan. 1956	34	50	18	2.24	–	–
Feb. 1956	34	44	12	2.07	–	–
March 1956	–	–	–		62	3
April 1956	19	0	0		–	–
May 1956	–	–	–		123	0.8
July 1956	21	0	0		–	–
Sept. 1956	40	0	2?		62	2
Jan. 1957	10	0	0		–	–
Feb. 1957	18	0	0		–	–
March 1957	8	0	0		–	–
June 1957	8	0	0		–	–

by internal macroscopic examinations of dead-trapped animals. External observations of live-trapped females were supplementary for periods in which few or no dead-trapped specimens were available. Individuals were presumed to be adults if they weighed 55 grams or more. Females which were lactating while pregnant were reported only as pregnant (Tables 2 and 3; Fig. 1).

Earlier reports.—Earlier workers described reproductive conditions among kangaroo rats of the southern Great Plains during brief, discontinuous periods (Table 1). The records suggested that reproduction was confined mostly to fall and winter. Breeding apparently began late, rate of reproduction was low, and population declined during the winter following the 1940 drought. Breeding began early, reproductive rate was high, and the population became dense following the favorable growing season for plants in the wet year, 1941. After another favorable growing season, 1942, population remained dense while rate of reproduction was low.

Kangaroo rats apparently gave birth during late summer or early fall, 1949, and also in December. Occurrence of the early fall births was suggested to us by a graph depicting total-length classes of kangaroo rats (Frank, unpubl. thesis, Okla. State Univ., 1950). There was no record of the percentages of pregnant females dead-trapped during the field work of October–November 1949.

Texas study area, 1954–1957.—There was some breeding activity among kangaroo rats near Canadian, Texas, in November–December 1954 (Table 2).

Several young weighing 37 to 45 grams were also caught during that period. Their weights suggested that they left the natal burrows only a short time before their capture. The percentage of females with evidence of recent reproductive activity had declined by the next trapping period, March 1955. At that time, the population density was low, approximately 2.5 animals per acre, suggesting that the reproductive rate was low in 1954–55 following the dry growing season of 1954.

Throughout the period from April to mid-August 1955, the population was sparse and sedentary, and kangaroo rats were reproductively inactive. Trapping success was low despite intensive trapping effort. In August, all live- and dead-trapped *Dipodomys* were mature (55 grams or more).

The period from mid-August 1955 to February 1956 was one of intensive reproductive activity on the Texas study area (Table 2, Fig. 1). Population density increased from less than 3 animals per acre in August 1955 to between 6 and 9 animals per acre in April and May 1956. In January 1956, near-term fetuses occurred in three of the animals that had enlarged vulvas characteristic of proestrous ovarian development (Pfeiffer, 1956, 1960). This suggested that older females were producing more than one litter per season and that estrus occurred in these cases immediately after parturition.

Young kangaroo rats first appeared in the traps in November 1955. These early young matured and seemed to make up most of the enlarged breeding population by February 1956. As suggested below for the Oklahoma animals, litters produced by these young females tended to be smaller than those of

TABLE 3.—*Breeding periodicity suggested by reproductive conditions of adult female kangaroo rats, Harper and Woodward Counties, Oklahoma*

Trapping period	Dead-trapped				Live-trapped	
	No. examined	% pregnant	% lactating	No. embryos per pregnant female	No. examined	% with vulva swollen
Aug.–Sept. 1956	9	0	0		41*	2
Nov.–Dec. 1956	12	0	0		–	–
Dec. 1956–Feb. 1957	–	–	–		28*	32
Jan.–Feb. 1957	11	0	9		–	–
July–Aug. 1957	9	0	0		10*	0
Sept. 1957	–	–	–		32*	91
Oct. 1957	33	70	30	3.61	38*	100
Nov.–Dec. 1957	42	55	21	3.22	–	–
Jan.–Feb. 1958	38	47	18	2.78	–	–
March 1958	14	64	0	3.33	–	–
April 1958	22	0	0		–	–
May 1958	93	0	0		70	0
June 1958	17	0	0		23	0
July 1958	2	0	0		60	0
Aug.–Sept. 1958	16	0	0		114	11
Oct.–Nov. 1958	20	0	0		–	–

* These live-trapped females were not weighed, but all appeared to be of adult size.

older ones. The Texas data do not suggest that the incidence of second litters was high.

In contrast to the situation of 1955–1956, there was almost no reproduction on the Texas area during the fall and winter of 1956–1957, following the very dry growing season of 1956. Pregnant or lactating individuals were not observed except for two which were probably lactating when taken in September 1956 (Table 2). Most females observed that month had perforate orifices but swollen vulvas were rare. Presumably the population approached the threshold of reproductive activity but did not cross it in the fall of 1956. The estimated population declined to 1 or less kangaroo rats per acre by June 1957.

Intensive sampling of available seed supplies during most of the Texas study suggested that the population decline of 1956–1957 resulted from reduced production of weed and grass seeds during the drought year of 1956 (Inglis, 1959). Good spring rains, followed by moderate seed production in 1955, resulted in supplies in excess of kangaroo rat needs for food and storage in late 1955. Drought, followed by insufficient seed production and much larger rodent populations, presumably induced the decline in *Dipodomys* numbers in 1956–1957. The pattern of drought and food shortage apparently had a major influence on reproductive activities of kangaroo rats. Further work is being done by Inglis on the mechanics of this interaction.

Oklahoma study area, 1956–1958.—There was much similarity in observations on the Texas and Oklahoma areas when the two studies were concurrent; i.e., August 1956 to June 1957. As on the Texas area, there was almost

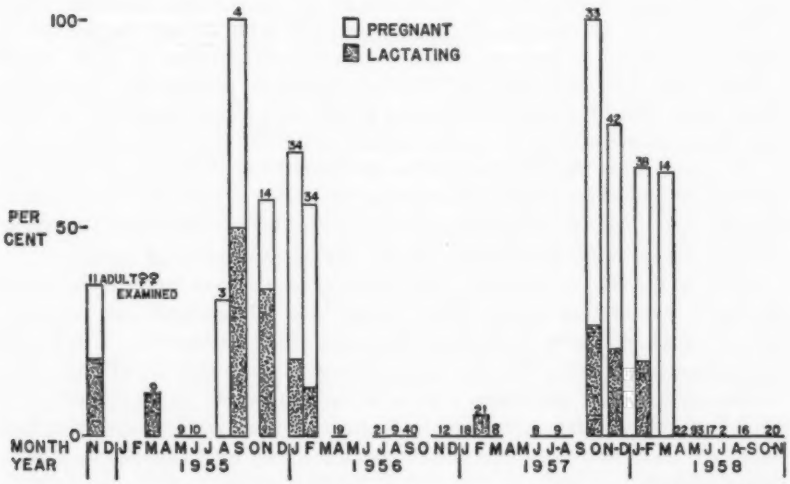
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FIG. 1.—Seasonal fluctuations in evidence of breeding in 590 dead-trapped female kangaroo rats of adult size (55 g or more), Hemphill Co., Texas, and/or Harper and Woodward Co., Oklahoma.

no evidence of reproduction among kangaroo rats near Fort Supply, Oklahoma, in fall and winter of 1956–1957, following the 1956 drought (Table 3, Fig. 1).

Population declined on the Oklahoma area during the very dry winter which was followed by a spring of prolonged and abundant rains. Estimated density on one live-trapped area was 7 rats per acre in August 1956 but only 2 per acre by July 1957. Reproductive quiescence apparently continued throughout the spring and until late summer of 1957.

Then, in contrast to conditions of the previous year, there was much breeding activity from September 1957 to March 1958 (Table 3, Fig. 1). Food seemed abundant for the sparse population at the start of that breeding period, following the good growing season of 1957. Breeding success was exceptionally high, as suggested by percentages of pregnant or lactating females. Large numbers of young had been born in late summer and early fall of 1957, and they suddenly began to appear in the traps in late October. From 29 October to 19 November, 67 of the 211 dead-trapped kangaroo rats were immature.

The first immature kangaroo rat of that breeding season was taken on 17 October 1957, which suggested that a small percentage of females had conceived in August. Incidence of pregnancy among dead-trapped adults suggested that about one-third had bred by the end of September and the other two-thirds conceived their first litters of the season in October and November.

Breeding apparently ceased in March 1958. There was no evidence of reproductive activity among kangaroo rats from April through August 1958. Breeding did resume in the fall of 1958, but incidence of pregnancy (Table 3, Fig. 1) then was strikingly reduced from that of the previous fall. Only 5 per cent of all trapped individuals were immature in October and November 1958.

This low rate of reproduction was associated with several factors which might have tended to suppress it. Plant growth was abundant in 1958. Much food was produced, but there may have been increased competition for it in the fall of 1958. The *Dipodomys* population densities then were estimated at more than three times as great as in late summer of 1957. Also there were much greater numbers of other rodent species which might tend to compete for food, burrows or other necessities. The summer of 1958 was noted for an irruption of cotton rats, *Sigmodon hispidus texianus*, on the areas studied where kangaroo rats had been the most numerous species during most years of record.

Litters at the start of the 1957–1958 breeding season were larger than during the latter part of that season. The average was 3.37 embryos per pregnant female for 46 specimens in October–November 1957. It was only 2.76 for 29 during January–March 1958. The mean difference was highly significant. This further suggests that conditions were extremely favorable for reproduction in the fall of 1957. By late winter, when litters were smaller, the population had increased, there was less space per kangaroo rat, and food supplies may have been depleted.

Rate of reproduction also may have been associated with age composition of the population of breeding females. There seemed to be some tendency for

old females to have larger litters than the young adults. Specimens were grouped in these relative age classes on the basis of degree of wear on molariform teeth. The mean difference in number of embryos per female, however, was not statistically significant in this comparison of age classes.

The older adult females apparently produced at least two litters each during the 1957–1958 breeding season. This was suggested by several factors. One was the large percentages of juvenile kangaroo rats among those trapped throughout that winter (McCulloch, unpubl. thesis, Okla. State Univ., 1959). Another was that mammae of the live-trapped females remained enlarged from September to March. Another, that all of the dead-trapped adult females had recently borne young or were about to do so in October 1957, whereas pregnancy was also common (54%) among dead-trapped females of this older class during the latter months of that breeding season.

Pregnancy was usually difficult to detect with certainty in live-trapped animals. However, one live-trapped kangaroo rat appeared gravid in March 1958; her abdomen was extremely swollen. That pregnancy may have indicated her second, if not her third, litter of the 1957–1958 season. She appeared to have been suckling in October 1957 and her nipples remained enlarged throughout the winter.

Young female kangaroo rats born early in the 1957–1958 breeding season had litters before that season ended. Individuals born during the latter part did not. Females appeared capable of breeding, i.e., some contained embryos, at about 2 months of age. The age estimates were derived from the earliest date of breeding evidence among the population, an assumed 30-day gestation (Day *et al.*, 1956) and a nestling period of 3 or 4 weeks.

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THE DISTRIBUTION AND MOVEMENT OF ROOF RATS ON MONA ISLAND, WEST INDIES

BY WARREN F. PIPPIN

ABSTRACT: Rat-trapping operations on Mona Island, West Indies, indicate the only species present on the island is the roof rat, *Rattus rattus*. In a one-year period, 237 specimens were collected; 71 rats were marked and released; 41 (57.7 per cent) were recovered at least once. Forty of the marked rats were released in areas other than where captured. The recovery in this group was 16 (33.3 per cent). The rate of recovery of the rats liberated where they were originally captured was almost 85 per cent.

The Norway rat, *Rattus norvegicus* (Erxleben), and the roof rat, *Rattus rattus* (Linnaeus), are the two principal known reservoirs of typhus in the Caribbean. Information is limited on the occurrence of these animals and their ectoparasites on small islands that dot the area. In view of this, a study of rats and their ectoparasites was conducted on Mona Island, West Indies, from 1 December 1954 to 30 November 1955. It is the purpose of this paper to present information on the distribution and movement of *Rattus rattus* on this island.

Mona Island is located at Lat. 18° 05′ N, Long. 67° 55′ W, in the middle of Mona Passage. It is about 45 miles west of Mayaguez, Puerto Rico, and 40 miles east of Punta Espada, Dominican Republic. The island is politically part of Puerto Rico. Shaped like a lima bean, with the concave shoreline on the north, the island is about 6 miles long from west to east and 4½ miles wide from north to south. The total area is 13,640 acres. Additional information on topography, climate, soil, vegetation, fauna and flora can be found in condensed form in Ramos (1946). With the exception of three members of the Coast Guard, the island had been uninhabited for a number of years.

Extensive information is available on the ecology of Norway rats, particularly in the reports published by workers of the Rodent Ecology Project at the Johns Hopkins School of Hygiene and Public Health (Davis and Emlen, 1948;

Emlen and Davis, 1948; Emlen *et al.*, 1948; Davis *et al.*, 1948). Considerably less information exists on the roof rat, particularly in rural areas.

Ecke (1955) states that feral roof rats are seldom found in southern Georgia. Roof rats are frequently encountered in fields, fence rows, and at the edge of swamps, sometimes several miles from a house or barn, indicating a less tenacious association with mankind than the Norway rat (Worth, 1950). There is evidence that roof rats trapped and liberated in the same areas tend to remain, and do not wander far (Baker, 1946; Worth, 1950; Spencer and Davis, 1950).

Trapping operations.—Since the study was intended to discover the species of rats present and their movement on the island, traps were set in as many different habitats as possible. The trap used was a wooden box trap similar in construction to that described by Richter and Emlen (1945). The traps were baited with fresh apple, which proved satisfactory. The traps were distributed in the afternoon and checked the following morning. If specimens were taken, a record was made of the location and type of habitat.

Transportation difficulties between Puerto Rico and Mona Island prevented a systematic trapping schedule. It was possible, however, to collect data for each month of the year. During the 12-month period, 237 specimens of *Rattus rattus* were captured. The rats were captured in greater numbers during May, June and July. The number captured during the summer months reflects a

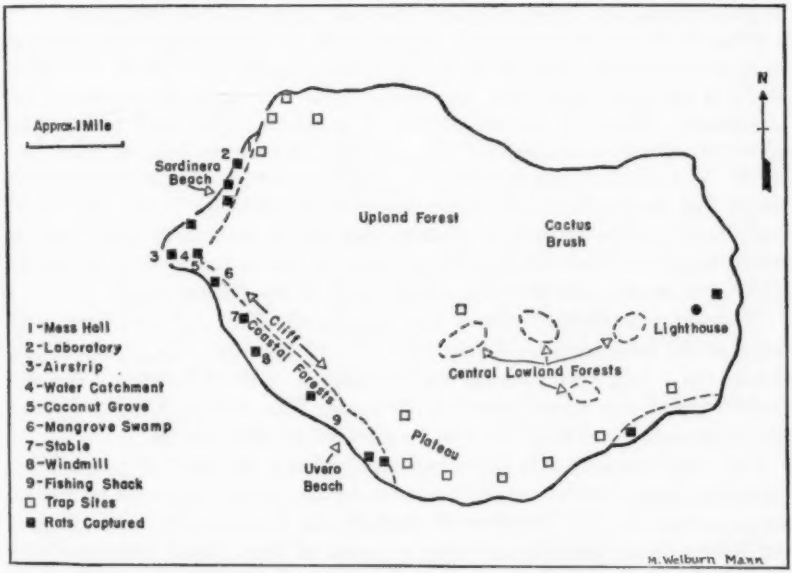

FIG. 1.—Mona Island, showing physical features, habitat types, sites where traps were set and rats captured, and capture and release points for movement studies of *Rattus rattus*.

greater trapping effort and not necessarily a fluctuation in the rat population. The total of 237 rats includes those captured more than once. Seventy-one rats were marked by the ear-notching and toe-clipping method and released for movement studies.

Habitat preference.—The roof rat was the only species found on Mona Island and was most common on the low coastal plain. Abandoned man-made structures were the preferred habitat. Every building on the coastal area supported at least one family of rats and the larger structures, such as the old Civilian Conservation Corps mess hall, several. Rats were also found under brush piles in the coconut groves, near water catchments, on the brush-covered airstrip, and occasionally near the mouth of caves at Sardinera Beach. A small colony was also found on the beach near the lighthouse, where the Coast Guard personnel maintained a flock of chickens (Fig. 1).

With the exception of six rats taken at the lighthouse, no individuals were trapped on the plateau. The extreme difficulty of penetrating the brush and cactus on the plateau necessitated the placing of traps near the road and along established trails. Localities where traps were placed and rats caught are indicated on Fig. 1. It is quite possible that rats occur in areas of the island that were not accessible for trapping.

Movement.—The ability of roof rats to find their way back to their home habitat, after being removed some distance and liberated, has not been studied to any extent. Most studies have been made by releasing the rats in their original habitat and trying to determine their dispersal from this point.

From 10 May 1955 through 12 August 1955, 40 marked rats were released in areas at varying distances from their original point of capture. Of these, 16 (33.3 per cent) were later recovered. Table 1 presents the results of this experiment. Of the 16 rats recaptured, 11 made their way back to the point of initial capture, indicating this was probably their home habitat. Rats Nos. 28, 37, 38 and 71 (Table 1) present a different picture. There is some indication that these rats moved about between the buildings in the old C.C.C. camp area and the improvised airstrip. Rat No. 31 apparently was trying to return to its home habitat, the fishing shack, as it was captured at the stable, which was on the road from the release point to the fishing shack.

The most remarkable recovery was rat No. 41. This individual was captured at the laboratory on 5 July and released the same day at the fishing shack. On 7 July, this same rat was recaptured at the laboratory. The distance traveled was approximately 8,700 yards. This was the longest distance any rat traveled, and is believed to be a record for this species.

The lower recovery rate (33.3 per cent) of rats liberated at points other than their home habitat, suggests something may have happened to the remaining individuals. A number of marked rats, for example, were taken to the fishing shack and released over a period of time. Only two were ever recovered and these had returned to their original habitat. During the same period, several rats were captured in this area, released and later recaptured.

Movement between population units.—Of the 41 marked rats recovered, five (12.2 per cent) were taken in an area other than their original point of capture. The rats that were marked and released in the area where they were captured were never recovered more than 50 yards from that area.

Discussion.—The result of trapping 237 rats on Mona Island, West Indies, during the period 1 December 1954 through 30 November 1955, indicates the only species of rat found on the island is the roof rat, *Rattus rattus*. No rats were found on the plateau, with the exception of a small colony near the

TABLE 1.—*Movement of rats shown by trapping records*

Rat No.	Date and original point of capture	Liberation point	Date and recapture point	Approximate distance traveled, yd
1	10 May, Mangrove Swamp	Laboratory	11 May, Mangrove Swamp	1,100
4	11 May, Water Catchment	Windmill	12 May, Water Catchment	1,700
14	20 May, Mess Hall	Laboratory	5 June, Mess Hall	350
28	7 June, Airstrip	Airstrip	9 June, Laboratory	600
30	7 June, Laboratory	Mess Hall	7 July, Laboratory	350
31	7 June, Fishing Shack	Mess Hall	15 July, Stable	1,500
32	8 June, Airstrip	Mess Hall	6 July, Airstrip	950
"		Stable	11 July, Airstrip	850
37	5 July, Airstrip	Airstrip	7 July, Mess Hall	950
38	5 July, Mess Hall	Mess Hall	6 July, Airstrip	900
"		Stable	11 July, Airstrip	850
40	5 July, Laboratory	Mess Hall	7 July, Laboratory	350
"		Stable	11 July, Laboratory	1,400
41	5 July, Laboratory	Fishing Shack	7 July, Laboratory	8,700
42	5 July, Mess Hall	Stable	11 July, Mess Hall	1,500
51	7 July, Mess Hall	Stable	12 July, Mess Hall	1,500
53	7 July, Laboratory	Stable	11 July, Laboratory	1,200
58	13 July, Coconut Grove	Fishing Shack	21 September, Coconut Grove	4,400
71	12 August, Mess Hall	Mess Hall	25 August, Laboratory	350

lighthouse. Lack of water and the relatively small known food supply probably limits the rat activity to the low coastal areas. It was not possible to trap in all sections of the island, and there may be rat colonies in these areas. It was quite evident the rats preferred man-made structures for harborage.

The low recovery rate of the 40 rats liberated in areas other than their home habitat suggests that a high percentage did not survive. What did happen is not clear, but the possibility exists that the rats may have been destroyed by other rats who occupied the area where the marked rats were released. There is probably a rather delicate balance between the rats in any given area and the available food supply, and any factor that would upset this balance would likely be resisted vigorously.

Of the 16 rats recaptured after being released away from their home habitat, 11 (69 per cent) had returned to their original point of capture. This suggests a strong tendency to find their way back to their home range. Rats that were marked and released in the area where they were captured were never recovered more than 50 yards from that area. This would support the findings of Worth (1950) in Florida, Spencer and Davis (1950) in Hawaii, and Baker (1946) in Guam, who showed roof rats do not stray far from their home range.

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ECOLOGICAL AND GEOGRAPHICAL STUDIES OF *RATTUS RATTUS* IN MALAYA

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Abstract: As the systematic status of three so-called "forms" of *Rattus rattus* in Malaya is uncertain, the ecological and geographical distribution of two of these rats, *diardii* and *jalorensis*, was studied. Trapping of rats on Singapore Island showed that *diardii* occurred in a much wider range of habitats than on the mainland, due primarily to the absence of *jalorensis* and *argentiventer* from most of Singapore Island. The race *jalorensis* was trapped for the first time on the northwest coast of Singapore Island; it must have moved here from the mainland recently, as it was not trapped in other parts of the island. A detailed study of two areas where both *diardii* and *jalorensis* occurred showed that *jalorensis* was more successful in mangrove forest and belukar (or scrub), from which *diardii* appeared to be driven out. There was very little overlapping between the two types of rats in these areas. The geographical distribution of *diardii* and *jalorensis* in Malaya indicates that the former is spreading northward and the latter southward. On the basis of ecological preferences, it is concluded that *diardii* and *jalorensis* are subspecies of *Rattus rattus*.

The species *Rattus rattus* is represented on the mainland of Malaya by three distinct types which occupy three distinct habitats. These have been called different forms of the same species by Chasen (1933). Since then, no systematic study of these rats has been made. As the term "form" has no status in present-day systematics, a comparative study of some populations of *Rattus rattus* in Malaya was undertaken to clarify their taxonomic status. Only two types, *diardii* and *jalorensis*, were studied. The third described rat (*argentiventer*) could not be easily obtained and was not considered in the present study. The races *diardii* and *jalorensis* are also important hosts of the mites *Trombicula deliensis* and *T. akamushi*, vectors for the scrub typhus virus (Harrison and Audy, 1951). Any new information obtained about these would have added interest. Moreover, it is generally believed that the species *Rattus rattus* originated in this part of the world, and spread thence into other parts. More information about these rats might clarify their evolutionary significance. A number of studies on speciation and subspeciation have been carried out in the temperate regions. Very little work of this nature has been done in the tropics. A study of the factors which control speciation in the tropics, and whether these factors differ from those in northern latitudes, seems appropriate.

Some work on the ecology and geographical distribution of *Rattus rattus* has been done by Chasen (1933, 1940) and Harrison (1957). The three races are known to be ecologically distinct—*diardii* is essentially a house rat; *jalorensis* is a rat of scrub, wasteland and secondary forests; while *argentiventer* is a rat of grassland (usually *Imperata cylindrica*) and ricefields but is never found in villages or in houses adjacent to the ricefields (Chasen, 1933; Harrison, 1957). To understand the systematic status of *diardii* and *jalorensis*, it was necessary to study their ecological preferences and geographical distribution in the area concerned, as well as to observe the extent to which their ranges

overlap, and especially how much one excludes the other from any particular area. A trapping program was therefore organized in Singapore and South Johore. Some trapping was also done at Kuala Tahan (headquarters of King George V National Park) in Central Malaya.

Method of trapping.—Live traps were used which could only catch one animal at a time. Rats caught in these traps were not injured and could remain alive in the field for at least a day. The wire mesh was small enough to prevent the escape of even the youngest rats.

A particular area was selected and usually 50 traps were set in the area at one time. The traps were as widely distributed over the area as possible. They were left out for a maximum period of four nights. The traps were usually set on Monday evenings and checked every morning; on Friday mornings all the traps were collected and brought back to the laboratory. Traps which caught rats and were thus removed on one of the earlier mornings were not replaced. For some time traps were checked both in the mornings and evenings but it was found that no rats were caught in the daytime—hence checking of traps was later limited only to the mornings.

Areas trapped.—Trapping on Singapore Island was confined to the rural areas for two reasons: (a) to study the habitat of the *diardii* rats outside the city (the City Health Department was trapping rats within the city area), and (b) to find out whether *jalorensis* was present on Singapore Island, since this form was thought most likely to occur in the rural areas of the island.

The areas in which trapping was carried out on Singapore Island and South Johore and the types of rats trapped are summarized in Fig. 1. These areas may be divided into various ecotypes. A short description of each ecotype and the types of rats trapped there are given below.

1. *Regenerating forest* (Plate I) is the young developing forest in which the original forest trees have been felled and are replaced by new forest trees. It is found in the Catchment area on Singapore Island. Trapping was done in regenerating forest in the Catchment area off Mandai–Nee Soon Road adjacent to the Seletar Reservoir in the middle of Singapore Island. Most of the trees found in this area belong to the dipterocarp family. Although there is not much undergrowth in the primary forest in Malaya, the regenerating forest has some undergrowth as the trees are not tall enough or the branches thick enough to prevent light from reaching the ground. *Gleichenia* and *Stenochlaenia* ferns and some sedges form the principal constituents of the undergrowth in this forest. Three types of rats were trapped in this area: *Rattus annandalei, R. r. diardii* and *R. exulans.*

2. *Belukar* (Plate I) is the local term for scrub type secondary forest. Three main types of plants are common in the belukar, viz., *Melastoma malabathricum, Adinandra dumosa* and *Wormia suffruticosa.* Usually ferns, especially *Gleichenia* sp., are important constituents of belukar. Some pitcher plants (*Nepenthes* sp.) and a few grasses are also found. Trapping in belukar was carried out at 11th mile, Upper Thompson Road near Nee Soon. In the Upper

Thompson Road area the same three types of rats were again found, i.e., *R. annandalei, R. r. diardii* and *R. exulans.*

3. *Mangrove forest* (Plate II) is found within tidal range and just above high-water tide level, sometimes extending a good distance beyond this level. Usually it has a muddy bottom. The common types of plants found are *Avicennia alba, Rhizophora muculata* and *Bruguiera* sp. *Acrostichum ovium, Hibiscus tiliaceus, Pandanus* sp. and *Sclera* sp. are also found in the higher levels of the mangrove forest. Trapping in mangrove forest was done in three different areas at Lim Chu Kang, at the end of West Coast Road at Kg. Tg. Penjuru and at the 3rd and 4th miles, Main North Road, Johore Bahru. At Lim Chu Kang in Singapore, three different types of rats were either found in mangrove forest or in belukar close to the mangrove forest: *R. exulans, R. r. diardii* and *R. r. jalorensis.* The significance of *R. r. jalorensis* being found on Singapore Island is discussed below. The extent to which the ecological ranges of the two types of *Rattus rattus* in these particular habitats overlapped is also discussed below. At Kg. Tg. Penjuru, on the south side of the island, only *R. r. diardii* and *R. exulans* were trapped. On the mainland opposite Lim Chu Kang, at the 3rd and 4th miles Main North Road, Johore Bahru, *R. r. diardii, R. r. jalorensis* and *R. exulans* were trapped in mangrove.

4. *Lallang* (Plate II), composed of the grass *Imperata cylindrica,* covers large areas of wasteland in Malaya. Trapping in lallang was done at the 11th

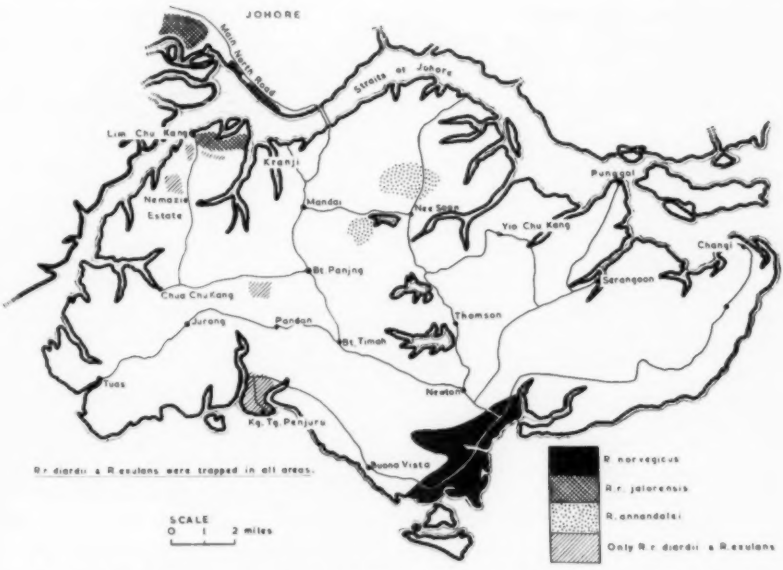

FIG. 1.—Map of Singapore Island and South Johore showing the areas where trapping was done and the types of rats caught.

mile Upper Thompson Road, at Kg. Tg. Penjuru, and at the 2d and 8th miles, Main North Road. All types of rats trapped were found in lallang at one time or another. At Upper Thompson Road, *R. r. diardii*, *R. exulans* and *R. annandalei* were taken in lallang. At Kg. Tg. Penjuru *R. r. diardii* and *R. exulans* were caught in lallang, while at the 8th mile, Main North Road, both *diardii* and *jalorensis* were trapped. At the 2d mile, however, only *R. r. diardii* was trapped in lallang.

5. *Rubber estates* in which trapping was done can be divided into two types: (*a*) those that are tapped for latex and hence kept clear of undergrowth, and (*b*) those that are not tapped and hence overgrown with brush. In the clear rubber area at the 11th mile, Upper Thompson Road, near Nee Soon, *R. r. diardii* and *R. exulans* were trapped. In the rubber estate with undergrowth (also at 11th mile, Upper Thompson Road), *R. r. diardii* and *R. annandalei* were trapped. The undergrowth is usually of the belukar type with *Gleichenia* ferns being the most dominant plant.

6. *Bamboos*: Some trapping was done in clumps of bamboos in Singapore. *R. r. diardii* was the only rat found in the bamboo.

7. *Vegetable gardens*: Trapping in vegetable gardens and close to the houses of the gardeners in the rural areas of Singapore produced only *R. r. diardii* and *R. exulans*.

Trapping around the houses of the settlement at Kuala Tahan in King George V National Park, Pahang, produced only *R. r. jalorensis*, taken inside the houses and in the vegetable gardens and clear spaces close to the houses. *R. r. diardii* was not trapped there at all, while *R. exulans* was occassionally trapped inside the houses.

Analysis of trapping results.—Four types of rats—*R. r. diardii*, *R. r. jalorensis*, *R. exulans* and *R. annandalei*—were trapped on Singapore Island. No *R. norvegicus* was taken, as trapping was limited to the rural areas and this species is known only within the city area of Singapore (Searle and Dhaliwal, 1957). Chasen (1925) described *R. surifer* as a jungle rat caught on Singapore Island in 1908. No specimens of *R. surifer* were trapped, either in the secondary forest or in belukar. It is possible that with the advent of civilization it may have disappeared from Singapore Island.

Rattus rattus jalorensis was trapped at the end of Lim Chu Kang Road in Singapore on the northwest coast of the island. This is the first record of *jalorensis* from Singapore Island. A number of *jalorensis* were trapped close to Lim Chu Kang Road in mangrove forest and at the transition area of mangrove forest and belukar. A large number were also trapped further away from the main road in mangrove forest. Chasen (1933) records mangrove forest on the mainland as one of the habitats of *jalorensis*.

It is significant that *jalorensis* should be found in Singapore on the northwest corner of the island. Trapping in belukar close to Nemazie Estate only 2 miles away from the above area failed to produce any *jalorensis*. None was found in belukar at the junction of Kranji Road—Bukit Timah Road and close

to the Causeway between the mainland and Singapore Island. Trapping in various parts of the island in belukar, regenerating forest and mangrove forest, all of which are likely habitats for *jalorensis*, failed to produce any. Hence it

PLATE I

ABOVE: Regenerating forest showing the straight, smooth stems of young dipterocarp trees with very little undergrowth.

BELOW: Belukar or scrub type secondary forest; some ferns grow here as the bushes are not too close.

appears that *jalorensis* is restricted to the Lim Chu Kang area in Singapore. Specimens of *jalorensis* were also trapped in mangrove forest on the Johore mainland opposite Lim Chu Kang. Thus, these rats probably migrated recently across the Straits of Johore. Small fishing boats are known to ply across the

PLATE II

ABOVE: Mangrove forest at about high-water tide level.
BELOW: Lallang (*Imperata cylindrica*) growing on wasteland adjacent to a rubber estate, in the background.

Straits between these two points; *jalorensis* might easily have been introduced into Lim Chu Kang by this means.

R. r. jalorensis is well established in the mangrove forest at Lim Chu Kang. It appears to be moving westward as some specimens were trapped close to the edge of the mangrove forest with belukar. The Lim Chu Kang Road seems to have acted as a barrier to their westward movement, as some specimens were trapped on the east side of the road but none were taken in the belukar to the west.

Both *jalorensis* and *diardii* were trapped in the same area. No *diardii* were trapped in actual mangrove forest where *jalorensis* was already present. A brief description of the two areas where both *jalorensis* and *diardii* were trapped may help to clarify the situation.

Area 1 (Fig. 2).—Mangrove forest on the east mingles with belukar to the west. The Lim Chu Kang Road runs close to this belukar on its east side while on the west of the road is more belukar and lallang on slightly higher ground. A gravel road runs through the mangrove forest to a poultry farm about 300 m from the trapping area.

On the east side of the road the rats trapped in the mangrove forest and the mangrove forest and belukar transition region were all *jalorensis*, except for a single *diardii* in the transition zone. A few *diardii* and *R. exulans* were caught in traps placed along the gravel path but none of these was trapped in the mangrove forest. On the west side of the road, in belukar and lallang, *diardii* and *exulans* were trapped in large numbers. No *jalorensis* were trapped here. It appears that *jalorensis* has not yet migrated across the road. Harrison (1957) trapped *jalorensis* in grassland and scrub near Kuala Lumpur and *diardii* only

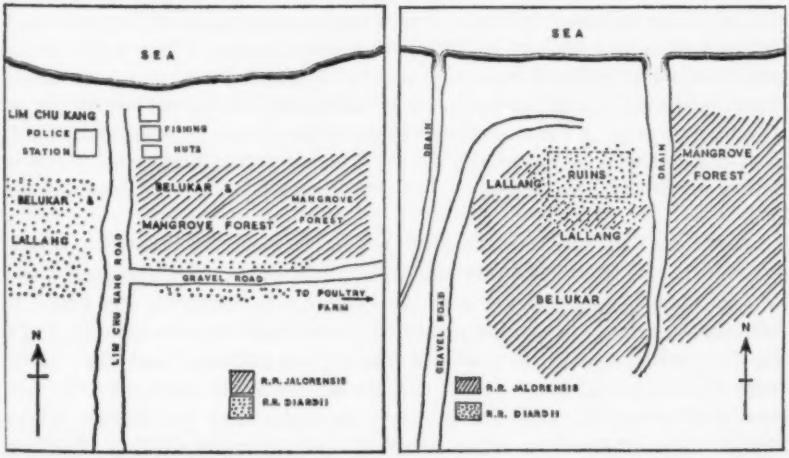

FIG. 2.—Details of two areas studied, with places where *R. r. jalorensis* and *R. r. diardii* were trapped. LEFT: Area 1, close to the Lim Chu Kang Police Station on Singapore Island. RIGHT: Area 2, about 2,000 m east of Area 1.

close to a path used for collecting firewood and close to the roads leading to houses.

Area 2 (Fig. 2).—This area lies to the east of Area 1 and is about 2,000 m from it. A deep tidal drain separates the mangrove forest on the east from lallang on the west (growing on and around the ruins of an old building). There is some belukar (mostly *Melastoma malabathricum*) to the south of the lallang area.

Rattus r. jalorensis was trapped in large numbers in the mangrove forest to the east of the drain as well as in lallang and belukar across the drain on the west. No *diardii* were trapped in the mangrove forest; some were trapped in lesser numbers than *jalorensis* in the lallang, especially around the ruins, but again none was trapped in the belukar.

Discussion.—Rattus r. jalorensis was trapped in fairly large numbers on the northwest coast of Singapore. This appears to be the only area where it is found on Singapore. It seems probable that it has been recently introduced.

Detailed study of the two trapping areas where both *diardii* and *jalorensis* were obtained brings up several interesting points. In both the areas, *jalorensis* has established itself in the mangrove forest and belukar but has not thus far spread beyond there. It is notable that in Area 1 *diardii* is restricted to the vicinity of the path, and in Area 2 to that of the ruins. This shows that *jalorensis* is more successful than *diardii* in mangrove and belukar and hence tends to drive *diardii* out once it is established. However, Lim Chu Kang Road and the gravel path in Area 1 act as a strong barrier to the spreading of *jalorensis*.

Specimens of *diardii* were taken in many habitats on other parts of Singapore Island—in regenerating forest, belukar, mangrove forest, grassland, rubber estates, clumps of bamboos, vegetable gardens and inside houses and shops in the city and rural areas. Absence of *jalorensis* in other parts of Singapore may be the reason why *diardii* was trapped in regenerating forest, belukar and mangrove forest although these are not its natural habitats. Chasen (1933) describes the ecology of the *diardii* rat as "essentially a house rat but also found in cultivated areas in the immediate vicinity of permanent human settlements." During the course of this study, *diardii* was trapped in Singapore in regenerating forest and belukar with the nearest human habitation at least 2 miles away.

Near Kuala Lumpur, Harrison (1957) found in one survey that *R. r. diardii* occurred in two houses but was only found five times in the grassland, three of these times being along a path used by the occupants of one house in collecting firewood. In another survey, *R. r. jalorensis* was numerous throughout the scrub area while *R. r. diardii* was trapped in houses and close to the roads leading to the houses. This and the above results show that the two types tend to exclude each other from any particular area. In Selangor, where there is competition from other types of rats (Harrison, 1957), *diardii* is restricted to houses and their immediate surroundings, while in Singapore it is found in many habitats, presumably because *jalorensis* is not widespread on

the island. On the east coast of Malaya and at Kuala Tahan (in the National Park), *jalorensis* enters houses from which *diardii* is absent. The two types of rats thus compete with each other, although each can occupy the ecological niche of the other if it is unoccupied.

Chasen (1933) says that, although the differences between these "forms" are as well marked as those which separate many species, they cannot be regarded as species because of the peculiarly restricted nature of their habitat. Neither does he see any justification for calling them subspecies, as the differences in their ranges are not geographical but ecological. This argument now has no basis, as ecological subspecies are accepted in present-day taxonomy. Dice (1940) records two subspecies of *Peromyscus* in the same geographical region but separated by their preference for woodland and open country, respectively. Mayr (1942:57) thinks that these divergences reaching subspecific stage must have arisen through geographical isolation preceding the ecological preference. It is a reasonable assumption that some form of geographical isolation preceded the present ecological isolation of *diardii* and *jalorensis*. This is particularly obvious if one looks at the geographical distribution of these rats.

Rattus r. diardii is not distributed throughout Malaya. It is the most common rat on Singapore Island, both in the city and in the rural areas, occupying every available habitat. In Kuala Lumpur it is fairly common and occurs even in the houses of aborigines built in the forest clearings (Harrison, 1957). It appears to be absent from Central Malaya and the East Coast. Trapping at Kuala Tahan, Central Malaya, revealed only *jalorensis* both inside houses and around houses. Harrison (1957) also records *R. exulans* and *R. r. jalorensis* in both houses and surrounding gardens. Harrison further shows that *diardii* is absent from Bentong and Kuala Lipis in Central Malaya and Kuantan on the East Coast. Kloss (1911) does not record *diardii* from Trengganu on the East Coast. This indicates that *diardii* is more restricted to southern Malaya. This rat, therefore, must have been recently introduced into Malaya and is in the process of spreading into Central and North Malaya.

Rattus r. jalorensis is more common in the north and east of the Malay Peninsula. Kloss (1911) records it from Trengganu in the northeast. Chasen (1940) records it from Junk, Seylon in South West Siam and the Penang Island off the northwest coast of the Peninsula. Harrison (1957) records it from Kuantan on the east coast. Since neither *jalorensis* nor any related rat is found in primary forest in Malaya, it must have been introduced into the peninsula from the north. Chasen (1933) distinguishes *jalorensis* in the north from the same type in the south of the peninsula on the basis of dorsal body color. In the present study it was found that *jalorensis* trapped in Singapore and South Johore invariably had darker dorsal body color than *jalorensis* trapped around Kuala Lumpur and Kuala Tahan in the north (unpublished data). Chasen thinks that *R. r. tikos* in the north is an insignificant link between *jalorensis* in the south and *R. r. thai* further north in Siam. *R. r. thai* is

a lighter colored rat, probably derived from the brightly colored, red-backed *R. r. khyensis* of Upper Burma. Thus, there is a graded series in dorsal color from the light-colored *thai* type in the north to the dark-colored *jalorensis* in the south. Presumably, *jalorensis* has been derived from *R. r. thai* in the north and there is a cline in dorsal color operating from the light type in the north to the dark type in the south.

It may be that *diardii* is derived from *jalorensis*, or is of foreign origin. The geographical distribution of the two rats makes it quite obvious that they originally were widely separated. Harrison (1957) infers that *diardii* is of comparatively recent introduction into Malaya. All available evidence points to the fact that, while *jalorensis* was introduced into Malaya from the north and has been spreading southward, *diardii* was introduced into the peninsula from the south and is in the process of spreading into the central, eastern and northern parts of the peninsula.

It may be concluded that the differences between *diardii* and *jalorensis* arose through geographical isolation. At present they have different ecological preferences but in the absence of one the other occupies its ecological niche. On the basis of this, these two types of rats should be called subspecies of *Rattus rattus*. Successful attempts at hybridization between the two subspecies were made in the laboratory; differences in pelage color and skeletal features were also studied. These results and their implications on the systematic status of these rats will be reported in later papers.

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BEHAVIORAL AND ECOLOGICAL NOTES ON *SPALAX LEUCODON*

By George E. Watson 3rd

Abstract: An adult female *Spalax leucodon* was maintained in captivity for one month in a soil-filled metal box. Its food consisted of root vegetables and large broad beans. Observations were made on burrowing techniques, defense, vocalization, nest building, and water requirements. Additional notes are included on the species' economic importance, local methods of capture, time sense, natural burrows, and distribution in the Aegean region. Convergent characters and behavior adapted to fossorial habits in unrelated and allopatric rodent evolutionary lines suggest that these various forms are ecological equivalents and that the subterranean herbivore niche is one with narrow limits.

The habits of the lesser mole rat, *Spalax leucodon*, are little known. Therefore, since I had the good fortune to capture one alive and relatively unharmed in eastern Thrace, it seemed worthwhile to list a few observations and notes on the behavior and ecology of the species in Greece and Turkey.

The rodent family Spalacidae, consisting of the single genus *Spalax*, is found in southeast Europe and adjacent Asia south to Egypt. Two or possibly three occur (Ellerman and Morrison-Scott, 1951). The mole rat's external morphology is highly specialized for a subterranean existence. The most noteworthy modifications are in the head, which serves as the main digging tool. The muzzle is flattened and broadened, giving a wedge-shaped appearance. A subcutaneous muscular ridge between the zygomatic arch and the nasal bone supports a line of short bristles on either side of the muzzle. Fine vibrissae are numerous on the cheeks and sides of the head. The long and strong lower incisors are exposed. Only the palate and the area immediately beneath the tongue have a mucous membrane lining; the rest of the interior of the mouth is covered with fur and effectively shuts off the oval opening during digging. There are no external openings for the minute eyes; the external ears are reduced to two meati. Head and jaw anatomy are discussed by Vinogradov (1927) and Reed (1958). The cervical musculature is strong and the "bull" neck appears massive. The blunt stocky body is covered with a soft, imperfectly reversible fur; the skin is rather loose. The legs and feet are relatively weak with small claws; the tail is reduced to a bare knob.

The Döring trap bruised the snout of the specimen, an adult female, so that its initial behavior probably was not typical. When removed from the burrow and released on bare hard earth, the animal made short forward "exploratory" runs of perhaps 30 cm, then backed up 10 cm, stopped, and moved off again at a different forward angle. When released in forest undergrowth, it likewise began searching, pushing its way under leaves and through grass tufts, but no digging was attempted. This is very different from the initial behavior of Reed's (1958) specimen which began digging at once.

The same day, it was put into a metal box of 80×30×40 cm with a wooden lid and containing some coarse loam and small stones. In this loose soil it burrowed freely after the first day so that, thereafter, I regarded the bruise of little importance and the animal's behavior normal.

Great difficulty has been experienced in keeping *Spalax* alive in captivity (Loisel, 1916; Pocock, 1917) although Montagu (1924) and Niethammer and Kummerlöwe (1934) maintained it successfully. My specimen lived one month in its metal box. The soil was about 15 cm deep and was occasionally dampened with water. In varying ratios, a superabundance of the following foods was maintained in the box: potatoes, onions, carrots, beets, and large broad beans. The animal seemed to prefer shelled broad beans over all other foods offered, suggesting that a low protein diet may be responsible for poor survival of some captives. At one point, when the loose lid was left open, the mole rat climbed out, toppled over and ate an entire small potted cactus. While eating, the mole rat steadied its food in its front paws, balancing its weight on the food as Loisel (1916) and Pocock (1917) also recorded.

Burrowing was accomplished mainly in the manner described by Niethammer and Kummerlöwe (1934) and Reed (1958). The front feet, working alternately, scratched out an initial 3 cm of soil; the hind feet kicking in unison jettisoned the earth. All this motion was very rapid. As soon as it had opened the hole about 3 cm deep, it thrust in its snout and, using much the same motion as a rooting pig, gradually insinuated itself into the soft soil by pushing the earth over its shoulders with alternate forward and downward shoves and forward and lifting thrusts of the head. Once the hole was large enough to admit the head, there was no more digging with the feet. Biting was observed whenever a small stone was encountered but the soft, uncompacted soil in the box precluded the gnawing postulated by Montagu (1924) and seen by Niethammer and Kummerlöwe (1934) on their host's wall plaster. The animal grasped the stone obstructing its prospective burrow in its teeth, dragged it by backing out of the hole, and jettisoned it nearby. If the hole were started where no foothold was available for leverage, the twisting movements Reed noted were seen, especially during the early digging. My animal turned at least 180°. With a side of the container as a firm foot brace, the animal rotated less and the initial hole was more nearly perpendicular. Released in a freshly ploughed field, the mole rat braced against a piece of sod and went through the same foot-scratching, stone-biting and head-thrusting actions. The great strength of the upward head thrusts is remarkable (Niethammer and Kummerlöwe, 1934). When well into the loose soil in the box, it continued digging by pushing its wedge-shaped snout ahead and lifting. Soil movements indicated its progress beneath the surface in loose substratum (cf. Loisel, 1916). After working through its burrows for a day, the soil appeared compacted enough through upward snout thrusts to allow free passage (Montagu, 1924).

This method of digging with the teeth and head is rare in burrowing mammals. More usual in fossorial rodents such as *Ctenomys* (Pearson, 1959) and *Heterocephalus* (Hill *et al.*, 1957), and also in marsupial and insectivore moles, is the primary use of the front limbs in digging. In these forms, however, the forefeet are strong and equipped with sturdy claws.

Reed's suggestion that loose soil is pushed through the burrow with the head

is strongly supported by my finding the majority of my field traps sprung and filled with loose earth. Only in clean burrows, especially those in damp or well-compacted soil, did I have much trapping success. Every trap set in a loose burrow was sprung by pushed soil.

In defensive posture on the surface, the animal opened its jaws wide, facing the direction of apparent danger, and often backed away slowly. When touched, it immediately changed its orientation to face its antagonist. Never did the animal attempt to escape by running. Blowing on the fur also induced defensive reactions. Hoarse hissing sounds were emitted when the animal was disturbed; only Niethammer and Kummerlöwe have recorded any *Spalax* sounds; theirs also emitted a hiss. Pearson (1959) correlated the lack of vocalization in most *Ctenomys* species with solitary existence.

If pressure were applied on top of a shallow burrow, the mole rat immediately thrust its head up, baring its incisors through the soil. The upward tilt of the head in defense implies that danger normally comes from above and the small proportion of *Spalax* bones in strigid pellets (Bate, 1945) suggests that either this defense is comparatively successful against smaller predators or that *Spalax* rarely forages aboveground. Hill *et al.* (1957) cite instances of unrelated African mole rats, working underground, being captured by owls. It is possible that larger owls such as *Bubo bubo* may take mole rats while they are pushing excess soil to the surface rather than when they are feeding outside the burrows.

Some leafy humus was added to the coarse loam in the box. Immediately the mole rat set about sorting out the larger pieces of leaves in order to construct a nest. Apparently it selected the leaves tactually with the muzzle and fine vibrissae. No other part of the body touched the leaves before the mole rat grasped them in its teeth and carried them to a corner of the box. Even though this entire operation took place on the surface and although the nest was to the side of the working animal, the mole rat backed up with the leaves in its mouth in order to put them in its nest. A few shreds of paper and onion skins added to the box also appeared in the nest pile. Montagu (1924) describes a nest chamber in a burrow similarly constructed of grass and onion skins. For a while this surface nest persisted as a diurnal resting place. Sleeping posture was similar to that of a domestic hamster, with the back hunched and the snout and paws tucked ventrally as the animal lay on its side. Later the nest was transferred underground. The size of the nest chamber described by Montagu implies that my animal did not at first find sufficient room underground in the box.

The mole rat made no apparent attempt to form a food store, perhaps because a superabundance was present in its box and frequently within easy reach of the nest. The corner farthest from the nest was used for defecation. No feces were found elsewhere on the surface. Their orientation suggested that the animal backed up to defecate.

Backing up instead of turning to change direction in searching, defense, nest-

building and defecation is demanded in a narrow burrow. The fact that the captive mole rat backed up in the same activities, even when on the surface, suggests that the behavior pattern of the animal is highly stereotyped for its more usual subterranean existence and that there is little plasticity in its surface behavior. New World geomyids and *Ctenomys*, however, turn in the burrows (Pearson, 1959). Such behavior is correlated with the fact that these animals have long fur, quite unlike the reversible pelage of *Spalax*.

A water container originally placed in the box was later removed since the animal apparently satisfied its water requirements from its root diet. This would be of obvious adaptive value in the dry parts of the animal's range. Although I found some burrows in damp ground near streams, most were in dry soil far from any source of water. Farmers on Limos occasionally opened mole-rat burrows and flooded irrigated fields to flush them out. The animals, I was told, then quickly appear on the surface. Perhaps the passage barriers, "Isolierungs" of Montagu (1924), serve to prevent natural or artificial flooding of the burrow rather than being, as he suggested, a conscious response to the animal's fear of detection from the surface. Loisel (1916) mentions "cisterns" that the animal makes in its burrow, but Montagu failed to find them. Water conservation and avoidance of excess dampness are characteristic of other fossorial rodents (Hill *et al.*, 1957; Pearson, 1959).

As Hill *et al.* (1957) point out, in arid areas extensive rodent burrows may allow aeration of the soil and permit sporadic rain to penetrate more deeply (see also Ingles, 1952). Nevertheless, in most parts of its range the mole rat is considered a serious agricultural pest. Onion and potato fields receive special attention and I was informed that large store chambers of root crops are found in its burrows. In addition to the water-flush technique already mentioned, the farmers employ a few other methods. The least successful try to dig the animal out (see Montagu, 1924). The more ingenious open a burrow near the surface and, placing a small stick in the end of the burrow, wait for the mole rat to close the hole. When the quivering twig indicates the animal's presence, its retreat is cut off with a shovel jammed into the passage behind it. An even more complicated arrangement is used in the Greek islands. A loaded shotgun is set pointed into the open burrow. A stick placed in the end of the burrow abuts on the trigger. The animal discharges the gun by pushing earth against the stick.

Mole rats and moles are commonly known as "Köstebek" in south and west Turkey and τυφλοπόντικος (blind mouse) and ἀσφάλακας in the eastern Greek islands. The last is a cognate form of ἀσπάλαξ used by Aristotle in *De Animalibus Historiae* for the mole rat.

Although my captive animal was chiefly active at night and was especially prone to making scratching sounds at 4 AM, probably in gnawing at the side of the metal box, the species may be active at any hour of the day. Under natural conditions, burrows were closed whenever I opened them in the field; two of my Turkish specimens sprung the traps while I was eating lunch. The animal

usually arrived less than half an hour after the burrow was damaged. Niethammer and Kummerlöwe (1934) mention a marked time sense in their specimen. In view of the lack of external eye openings, *Spalax* might make a good subject for "biological clock" experiments. It would be interesting to determine if the rudimentary subcutaneous eyes were light sensitive and therefore might serve to reinforce or reset the time sense.

Burrows investigated in the field varied in character with the soil type. The deepest I discovered was 75 cm in sandy clay on Limnos. In very loose plowed soil on Mytilene, burrows were just beneath the surface. Diameter of the burrows varied, probably according to the size of the inhabitant. The often highly conspicuous mounds are apparently made in getting rid of excess soil in the burrows. Seldom was the mound pushed directly up from the main passageway, but the animal dug a side horizontal passage up to 40 cm long, from the end of which a vertical passage led to the surface. Under some of the mounds, especially the higher ones which might reach 60 cm, the side and vertical passageways were completely refilled. This uneconomical but widespread arrangement is probably of survival value to the species and suggests that digging is comparatively easy. It possibly makes it more difficult for a digging predator to find a burrow, and certainly confused my fossorial attempts (see also Montagu, 1924). The mounds appeared most frequent (about every 45 cm) in rocky limestone soil but they were also present in damp highly organic soil near streams. The conspicuous fresh mounds with darker, damper earth are a common feature of dry limestone fields. Frequent open-end burrows were discovered on Megali Limni, a damp grassy field at 450 m, on Mytilene. The animals apparently kept the burrows open for nocturnal foraging. No mounds were seen but there were numerous burrow openings. This suggests that the closed mounds may help conserve moisture and cool the galleries. Protection against predators, especially snakes, may also be accomplished by plugging burrow openings.

Mounds were noted at all altitudes from just above sea level on a salt–clay bar covered with low *Salicornia* near Mersin, to 1,700 m on Mundan Ovasi above Fethiye, Muğla, in Turkey. Yearly rainfall, which is highly seasonal in the areas where burrows were seen, ranges from more than 200 cm near Elmalı, Antalya, and on Mundan Ovasi to 20–40 cm on the virtual desert to the east of Konya near Karapinar.

In addition to being locally common in Turkey, Macedonia, and Thrace, *Spalax leucodon* is definitely found on Samothrace, Limnos, Mytilene (Lesbos), and Euboea in the Aegean. No mounds or burrows were found on Samos nor did any of the local farmers know the animal.

Species of fossorial root-eating rodents occur on every continent except Australia and Antarctica. Remarkable convergent adaptations to a subterranean existence have led to uncertainty in their classification, but it is generally agreed that they are of polyphyletic origin (Simpson, 1945). Evidence for ecological equivalence with *Spalax* is derived from morphological, ecological,

and behavioral studies on Peruvian *Ctenomys* (Pearson, 1959), American Geomyidae (e.g., Ingles, 1952), African *Heterocephalus* (Hill et al., 1957), and Chinese Myospalacidae (Leroy, 1941). All of these forms dig extensive burrows, throwing up the same sort of mounds (although burrowing methods differ); none venture far, if at all, from their burrows; all feed primarily on roots secured underground and have no need for water other than that derived from food; and all are of about the same size. Further evidence of ecological equivalence is the fact that, with one exception, only a single phyletic group of fossorial rodents occurs in a given area. In spite of the fact that speciation has been rampant, seldom do two species overlap in both range and habitat. The only exception is the occurrence of the less strictly fossorial *Tachyoryctes*, a member of the oriental Myospalacidae, in eastern Africa where it overlaps with some species of Bathyergidae. As Pearson points out, it appears that world-wide there is but one rather limited niche available for exploitation by subterranean herbivorous mammals.

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INVESTIGATIONS OF THE ROLLING MECHANISM IN THE INDIAN HEDGEHOG

By B. B. GUPTA

ABSTRACT: In studies of locomotion and the defensive mechanism of rolling into a ball, in the Indian hedgehog, *Paraechinus micropus*, morphological observations were made on 12 specimens. The disposition of the skeletal parts during rolling, changes in the vertebral column and in the positions of the limbs and skull, are described. The rolling action is largely a voluntary function. Among specializations connected with this adaptation are modifications in the intervertebral discs and the presence of a supra-para-articular process on the thoracic vertebrae.

The phenomenon of rolling into a ball-like form is an interesting and important defensive adaptation in some mammals, such as those with a hard, tough, dorsal exoskeleton (armadillo, pangolin), or those with a dorsal coat of sharp spines and a soft ventral skin (echidna, hedgehog, porcupine). There has been but slight explanation of the mechanism of this rolling activity, except for the statement that a few cutaneous muscles are responsible for the rolling of the hedgehog. For a further investigation of this phenomenon the hedgehog was selected. The skeletons of 12 specimens were examined during the course of the study.

The Indian hedgehog, *Paraechinus micropus* Blyth, is well adapted to the harsh, arid region of Rajasthan, India. Rolling of its body is brought about by the approximation of the extremities, drawing the limbs closer to the body, and bending the head ventrally, bringing it between the forelimbs and ventral to the cervical region. All these changes occur through action of different muscles. In the present paper are described the skeletal changes which have been studied, with the aid of radiographs of living specimens (Plate I). The rolling is a voluntary action, mostly controlled by striated muscles. However, the presence of some smooth muscles between the bundles of striated muscles suggests that rolling is partly involuntary.

GENERAL BODY FORM

In the normal standing position the dorsal and lumbar vertebrae form an arch between the front and hind limbs, the anterior base at the seventh cervical vertebra and the posterior base at the midcaudal vertebrae (Plate I). The six anterior cervical vertebrae curve upward; the skull is directed anteriorly; the last caudal vertebrae point posteriorly. Both pelvic and pectoral girdles are

nearly parallel to the vertebral column. The pelvic girdle, with the ilium and sacrum fused, forms the broad posterior base of the body. In the pectoral region the cranio-vertebral angle rises above the level of the fourth thoracic vertebra, the cranial border slants ventrally, and the glenoid cavity is ventral to the seventh cervical vertebra. The axillary border throughout its length remains under the level of the vertebral column. The general configuration of the scapula differs in hedgehogs from that in other mammals. Its vertebral border does not lie parallel to the vertebral column, but is inclined at an angle of 30°. The limbs are plantigrade. The upper portions of the appendages have a double bend. The humerus is directed postero-ventrally with its distal epicondyle, near the xiphoid process, under the level of the sternum. The antebrachium is directed antero-ventrally. The position of the hind limb is the opposite of that in the forelimb—the femur is directed antero-ventrally and the shank postero-ventrally.

THE ROLLED-UP FORM

When the hedgehog assumes the defensive position, rolled up into a ball, the disposition of the skeletal parts is greatly altered (Plate I).

Changes in vertebral column.—The vertebral column, sigmoid in shape in the normal posture, becomes single-arched, with the extremities closer together, in the rolled-up form. Normally, the column measures 16 cm, in a straight line from tip to tip; this is reduced to 9.5 cm when rolled up. The cervical vertebrae, which were curved in a triangular form, become straightened and continuous with the rest of the dorsal vertebrae, forming a single arch. The caudal vertebrae also bend ventro-anteriorly to form part of the arch. Dorsally, the vertebrae are drawn apart, while ventrally they are compressed. They move easily on each other because of their long, broad articular surfaces. In rolling, the hedgehog's skull bends ventro-posteriorly and its articuation with the atlas shifts ventrally.

Changes in forelimb.—In the rolled-up animal, the scapula rotates; the cranio-vertebral angle shifts toward the skull; the axillo-vertebral angle pushes upward and occupies a position almost at the level of the vertebral column; the glenoid cavity moves ventro-posteriorly. The humerus lies parallel to the dorsal vertebrae and its distal end touches the coastal cartilage of the seventh sternal rib. The antebrachium and the humerus approach more closely, and the olecranon crest lies nearer the centrum of the ninth thoracic vertebra. The relative positions of the radius and ulna change, the space between them proximally increasing due to the pronation of the radius on the ulna. With the close approximation of the forelimb to the side of the thorax, the manus occupies a position under the bent head with the phalanges anterior to the hind limb and pointing downward.

Changes in hind limb.—The caudal vertebrae come to lie ventral to the pelvic complex. The distal end of the femur shifts dorsally and points antero-dorsally, occupying a position posterior to the last rib. The shank comes to lie

parallel to the femur, its distal end situated under the pelvic symphysis. The pes curves dorsally, posterior to and above the manus, with its phalanges pointing anteriorly (opposite those of the manus).

Changes in position of the skull.—Normally, the skull points anteriorly, its occipital condyles resting on the obliquely placed atlas. In the rolled condition,

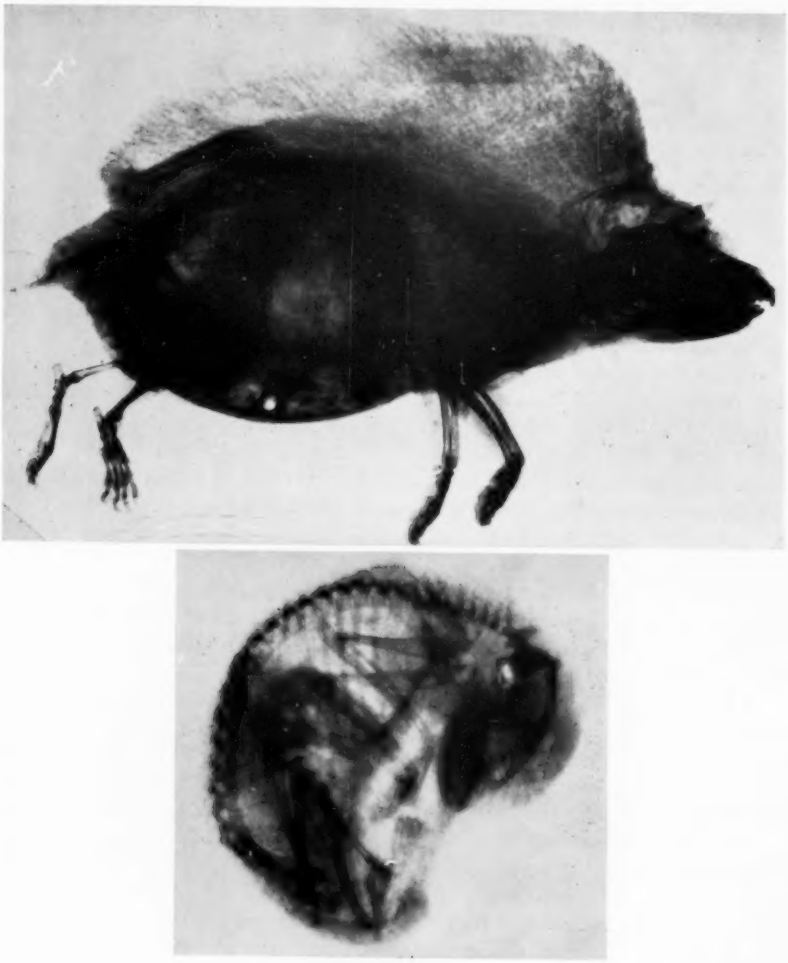

PLATE I

Radiographs of the Indian hedgehog, *Paraechinus micropus*, in the normal resting position (above) and in the rolled-up defensive position (below).

it bends to an angle of nearly 135° and points postero-ventrally, the snout closely approaching the last caudal vertebra. The ventral surface of the lower jaw comes very close to the sternum and lies between the folded forelimbs. This movement of the skull is brought about partly by the straightening of the cervical vertebrae and partly by the ventral movement at the articulation with the axis.

REMARKS

The skeletal changes during the rolling of the hedgehog reveal many special modifications. There is an extra para-articular process on the third and fourth thoracic vertebrae; the long, broad articular surfaces in general provide greater and closer contact between vertebrae, and also permit free movements. Straightening and ventral bending of the cervical vertebrae are extreme; shifting of the skull and the approximation to the caudal vertebrae help in creating the ball-like form of the hedgehog. Simultaneously, the limbs are drawn to the sides of the body, the spiny dorsal skin is pulled ventrally, and the soft ventral surface is pushed inward. Further, the action of the superficial cutaneous muscle (penniculus carnosus) brings the extremities closer. The animal assumes the shape of a ball of spines, the spines almost erect due to the action of the smooth muscles at their bases.

These observations on the skeletal changes during rolling of the hedgehog are preliminary to a discussion of the mechanics of the phenomenon, being prepared for another paper. It should be mentioned that the rolling appears to be largely a voluntary function, as it is controlled by striated muscles. However, the presence of a few bundles of unstriated muscles suggests the possibility that rolling may be partly involuntary in nature.

THE SUPRA-PARA-ARTICULAR PROCESS

Examination of the vertebral column disclosed the presence of an extra process, dorsal to the superior articular process of the third and/or fourth thoracic vertebrae. No such structure seems to occur in the related hedgehog, *Hemiechinus auritus*, which also inhabits Rajasthan.

Nathan (1959) described the "para-articular processes" of the human thoracic vertebrae as "located on the inner surfaces of the laminae in the immediate vicinity of the articular processes, without any apparent relation to disease of the vertebral column or to aging." There is relatively little literature on the family Erinaceidae, and even less on such structures on the thoracic vertebrae.

The *supra-para-articular process* is an anterior triangular projection from the transverse process of the vertebra (Fig. 1), dorsal to the superior articular process and as high as the level of the lateral facet for the tubercle of the rib. These processes are paired; they are most prominent on the fourth thoracic vertebra, but are present also on the third, though not so well developed. This process forms a hollow cavity dorsal to the superior articular process; into it fits the inferior articular process of the anterior vertebra.

It is difficult to homologize these processes with any others of the typical

vertebra. They are similar in appearance to the metapophyses (Gadow, 1933) dorsal to the anterior zygapophyses or superior articular processes. But the metapophyses are outgrowths from the latero-anterior aspect of the neural arch, arising broadly at a level between the spinous process and prezygapophyses, while the supra-para-articular processes of *Paraechinus* are anterior outgrowths of the transverse process.

Functionally, the supra-para-articular process appears to keep the vertebrae in close contact and prevent their displacement during rolling. In this action, the vertebral column is arched and the vertebrae separate dorsally. This process helps to maintain the relative position of the vertebrae, the inferior articular process of the vertebra ahead fitting between the supra-para-articular process and the superior articular process of the vertebra behind. Nathan (1959) attributed the function to the stability of the thoracic spine by the mechanical locking of the superior articular process of the vertebra below in the angle formed by the para-articular process and the inferior articular process of the vertebral column. Le Double (1912) regarded the para-articular processes as atavistic, i.e., vestiges of the zygosphenes found in the vertebrae of some reptiles. Shore (1931) considered their development as due to the strain of the ligamenta flava. Davis (1955) connected these structures with the "mortise joint" described by him.

I am of the opinion that these processes are most important in the locking of the thoracic vertebrae. The presence of similar processes in some reptiles points toward the primitive nature of the hedgehogs. The supra-para-articular process appears to be a generic trait, at least as between *Paraechinus* and *Hemiechinus*.

THE INTERVERTEBRAL DISCS

As in all mammals, flexible intervertebral discs are present between the bodies of adjacent vertebrae from the axis to nearly the last caudal vertebra.

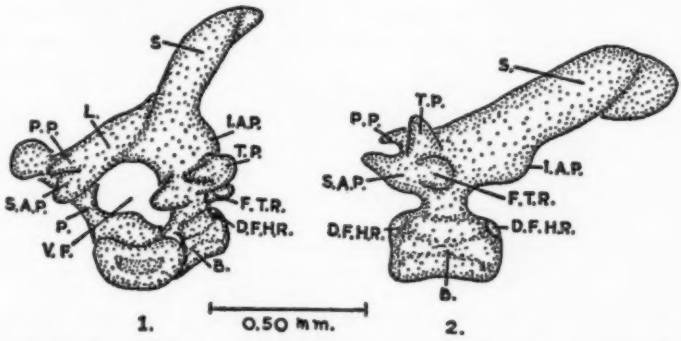

FIG. 1.—The fourth thoracic vertebra from an anterolateral view (1) and from a lateral view (2). B, body; DFHR, demifacet for head of the rib; FTR, facet for tubercle of the rib; IAP, inferior articular process; L, lamina; P, pedicle; PP, supra-para-articular process; S, spine; SAP, superior articular process; TP, transverse process; VF, vertebral foramen.

In the hedgehog, there are modifications in these discs associated with the changes in the vertebral column during the rolling and unrolling of the body.

Each intervertebral disc consists of a central, soft, pulpy, highly elastic substance, the *nucleus pulposus*. It is surrounded on the margins by a hard, fibro-

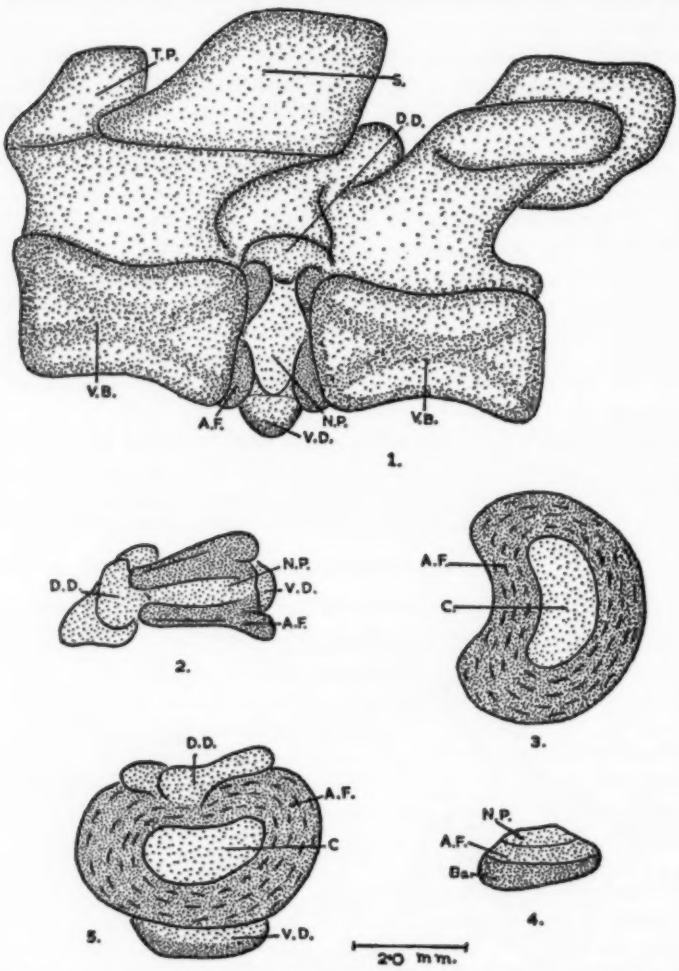

FIG. 2.—Views of vertebral discs: 1, longitudinal section of two sacral vertebrae with the intervening disc; 2, lateral view of the intervertebral disc; 3, antero-posterior view of the marginal fibrocartilaginous plate; 4, antero-posterior view of the ventral disc; 5, antero-posterior view of the intervertebral disc. AF, annulus fibrosus; B, base; C, central cavity; DD, dorsal disc; NP, nucleus pulposus; S, spine; TP, transverse process; VB, vertebral body; VD, ventral disc.

cartilaginous layer, the *annulus fibrosus* with concentric rings (Fig. 2). This fibrous layer is thicker toward the margin, thinner in the center. I have failed to find any hyaline cartilage covering either surface of the vertebral body in the hedgehog, as it does in most mammals. The fibrocartilaginous plates are separated ventrally by the nucleus pulposus. Dorsally, the two plates are more or less fused and have a disc-like covering of the soft material (the dorsal disc) toward the vertebral column. This may represent the remains of the notochord. Some of the posterior vertebrae possess an extra ventral disc between the fibrocartilaginous plates and the nucleus pulposus, representing the hypocentra. This ventral disc occurs between the last thoracic and the first lumbar, between all the lumbars, between the last lumbar and the first sacral, and in some cases also between the first two sacral vertebrae. In structure the ventral disc is similar to the fibrocartilaginous plate of the intervertebral disc, but it differs in shape. Its outer margin is more cartilaginous, its inner margin soft, thin and fibrous.

The thickness of the intervertebral discs varies in different regions. In the cervical region, the ratio of the length of the vertebral body to the thickness of the disc ranges from 2.5 : 1 to 1.7 : 1, with a larger nucleus pulposus between the fibrocartilaginous plates. In the thoracic region, the ratio varies from 2 : 1 to 1.7 : 1; in the lumbar region, from 2.7 : 1 to 2 : 1; and in the sacral region, from 2 : 1 to 1.8 : 1. The caudal vertebrae are relatively longer, with short intervertebral discs, and the ratio is 3 : 1. All these ratios are based on measurements at the ventral surface.

These variations in the shape and structure of the intervertebral discs in *Paraechinus micropus* indicate their importance in the actions of rolling and unrolling. The presence of more nucleus pulposus between the vertebrae points to more flexibility downward, particularly in the cervical and dorsal regions. The occurrence of hypocentra in the lumbar and sacral regions is associated with the greater pressure put upon these regions during bending of the vertebral column. The absence of the hyaline cartilage on the sides of the vertebral bodies may represent a primitive condition during the development of the vertebral column.

ACKNOWLEDGMENTS

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THE LARGE MOUSE-EARED BATS OF THE MIDDLE EAST, WITH DESCRIPTION OF A NEW SUBSPECIES

By David L. Harrison and Robert E. Lewis

Abstract: The greater mouse-eared bat, *Myotis myotis* Borkhausen, is recorded from Syria and Lebanon and a new subspecies is described, type locality 2 km east of Amchite, Lebanon. This bat exists together with the lesser mouse-eared bat, *Myotis blythi* Tomes, in certain localities in Syria and Lebanon. The forms *M. m. omari* Thomas (type locality Derbent, Iran) and *M. m. risorius* Cheesman (type locality Shiraz, Iran) are considered to be races of *M. blythi* Tomes, and it is considered likely that *risorius* is a synonym of *omari*.

There has been much confusion in the past regarding the status of the large mouse-eared bats which exist in the Middle East. It is generally accepted that two species occur in southern Europe, sometimes found in the same locality and even in the same cave. Miller (1912) pointed out that these two species are easily distinguished from one another because of the larger skull and external ears of *Myotis myotis myotis*, while in *Myotis blythi oxygnathus* both the skull and ears are outstandingly smaller (*vide also* Kuzyakin, 1950, Figs. 90, 91, p. 242).

The position in the Middle East, however, has not been hitherto at all clear or satisfactory. Thomas (1905) described a form from Iran, which he regarded as a race of *M. myotis* and which he named *M. m. omari* (type locality Derbent, 50 miles west of Isfahan). Cheesman (1921) described another Iranian form of very similar dimensions and followed Thomas in regarding this also as a race of *M. myotis*, which he named *M. m. risorius* (type locality Shiraz). Ellerman and Morrison-Scott (1951) listed these two bats as races of *M. myotis*, but Kuzyakin (1935, 1950) had already expressed the view that they were in reality representatives of the smaller forms *blythi* and *oxygnathus*, which Ellerman and Morrison-Scott (1951) believed to be conspecific. Kuzyakin has been followed in this view by Abelienthev, Pidoplichko and Popov (1956) and also recently by Aellen (1959), who believed *blythi* to be conspecific with *oxygnathus*, and *omari* probably a synonym of the latter. In view of all this uncertainty, it is hardly surprising that some authors have regarded the whole group as conspecific. Thus, Bodenheimer (1958) states that "the large Mouse-eared Bat (of Palestine), *Myotis oxygnathus* Monticelli 1885, is the Mediterranean vicariant of the European *Myotis myotis myotis* Borkhausen 1797." Theodor and Moscona (1954) list both *M. myotis* and *M. b. oxygnathus* for Palestine and quote *M. myotis* from N. Galilee, but without measurements or details from which to determine the status of these specimens precisely.

It is therefore of great interest to record that material recently obtained by one of us (R.E.L.) in a cave in Lebanon, and other material studied from a locality in Syria, clearly reveals the presence of two perfectly distinct species cohabiting the same roost in each case. They are, just as in the case of southern European material, distinguished by the great difference in skull and ear size (Plates II, III). The specimens with smaller ears and skulls have been com-

pared with the types and other material of *omari* and *risorius* and are identical in skull and ear size and in all essentials. This confirms the view of Kuzyakin. The material of each species will be described in detail.

Myotis myotis Borkhausen 1797, greater mouse-eared bat:

The larger animals now found in Lebanon and Syria are outstanding on account of their very large skulls. They are clearly the true Middle Eastern representative of *Myotis myotis*, hitherto unknown, and since they differ from all known forms of the species in certain particulars, we consider them to belong to a new subspecies, which we name:

Myotis myotis macrocephalicus nov. subsp.

Type specimen.—Adult male, obtained on 14 August 1960 in a cave 2 km east of Amchite, Lebanon. The type is located in the collection of the British Museum of Natural History. Collector's number V 6048.

TABLE 1.—*External measurements (in mm) of* Myotis myotis *Borkhausen*

Locality	Date	Coll., No.		Length	Tail	Hind foot	Forearm	Ear	Wingspan
M. m. myotis:									
Bad Segeberg, Schleswig-Holstein, Germany	21 Mar. 50	Harrison 4.977	♂	123	42	10.8	58	20	373
"	17 Jan. 51	7.1105	♂	–	33	14	56	21	380
"	21 Mar. 50	6.979	♀	123	43	13.2	62.2	27	358
"	"	2.975	♂	124	42	13.3	59.5	24	410
"	"	5.978	♂	115	37	12.8	57.7	23	381
Sibbe, Valkenberg, Holland	6 Jan. 48	1.715	♂	–	–	14	59	–	–
Meiringen, Switzerland	28 Oct. 55	8.1889	♂	–	–	13	59	–	400
"	"	9.1890	♀	–	–	12.8	57.8	–	360
Pisznice Cave, Hungary	24 May 57	10.3124	♀	130.4	54.2	14.5	63.3	25.8	432
Ordoglyuk Cave, Szoplaki, Hungary	15 Jan. 58	11.3125	♂	132.2	58.3	14.5	61.2	26.7	429
M. m. macrocephalicus:									
Tell Kalakh, Syria	8 Dec. 52	Collector's No. 3	♀	125	60	13.7	58.1	28	403
Cave, 2 km east Amchite, Lebanon	14 Aug. 60	Harrison							
"	"	12.3265	♂	136	59	16	67	28	–
"	"	Collector's No. V.6047	♂	136	59	16	67	28	–
		No. V.6050	♀	135	62	16	67	28	–
" TYPE	"	No. V.6048	♀	136	60	15	68	28	–
"	"	No. V.6024	♂	133	58	13	66	29	–

TABLE 2.—*Cranial measurements (in mm) of* Myotis myotis

Material	Greatest length	Condylobasal length	Zygomatic breadth	Breadth of braincase	Interorbital constriction	Maxillary teeth c–m³	Mandibular teeth c–m₃	Mandible
M. m. myotis:								
Harrison								
4.977	24.5	–	15.1	10	5	9.8	10.5	18
7.1105	23.2	21.6	14.5	9.8	5.2	9.1	9.9	17.4
3.976	23.8	21.9	14.8	9.8	5.2	9.2	10.2	17.8
6.979	–	–	15.2	9.9	5.0	9.8	10.8	18.7
2.975	24.5	22.3	14.8	9.9	4.9	9.6	10.2	18.1
5.978	24.3	22.2	–	9.9	5.2	9.6	10.3	18.1
1.715	24.4	22.3	15.1	10.1	5.1	9.8	10.3	18.1
8.1889	24	22.3	14.4	9.7	4.8	9.8	10.3	17.8
9.1890	23.3	21.2	14	9.8	5.1	9.3	10.1	17.4
10.3124	24.2	22.5	15	9.9	4.9	9.8	10.5	18.1
11.3125	24.5	22.5	14.9	9.8	5.0	10.0	10.5	17.9
M. m. macrocephalicus:								
Collector's								
No. 3	26.1	24.9	16	9.8	5.1	10.6	11.3	19.7
Harrison								
12.3265	26.2	24.5	15.9	10.3	5.2	10.3	11.3	20
Collector's								
No. V.6047	26	24.5	15.5	10.3	4.8	10.3	11.2	20.1
No. V.6050	25.9	24.3	15.6	9.9	4.8	10.3	11.1	19.6
No. V.6048	26.8	24.8	15.7	10.3	5.1	10.6	11.3	19.9
TYPE								
No. V.6024	25.3	23.9	16.1	10.0	4.8	10.0	10.8	19.1

Diagnosis.—Differs from the typical race and all other known races of the species in its larger cranial measurements (See Table 2) and paler color on the back. External measurements average larger than for *M. m. myotis* (See Table 1).

Description of the type.—Essential features like *M. m. myotis* from Germany but with the skull notably larger, attaining a greatest length of 26.8 mm. The dorsal surface is covered by hairs of which the basal half is dark slaty. Over the head, neck and rump the distal half of the hairs is pale buffy brown (closely matching B 5 Mavis Grain – Pecan +, Plate 13, Maerz and Paul, 1950). This is decidedly paler than the general tone in this region in the typical form. Blackish brown patches are present on each side in the scapular regions, as in the typical form, and they are associated with a slight darkening of the general brown tone in the mid-dorsal region, so that this mid-dorsal darkening is slightly contrasted with the pale head and nuchal region, while distally it fades gradually into the pale rump. The basal half of the hairs on the belly is slaty gray, the tips throughout the whole ventral surface whitish, with a slight buffy wash on the chest and belly. The wing membranes are dusky blackish in hue,

the ears and tail membrane brownish and semi-translucent, decidedly lighter than in typical *M. m. myotis*. The form of the ears and tragi does not differ significantly from the typical form, and there is no difference in the structure of the wings, calcar or feet. The skull is outstandingly larger and heavier than that of any example of the typical form seen, but it is similar in general proportions, exhibiting the narrower braincase and less outwardly bulging frontotemporal region than is seen in *M. blythi*. The sagittal crest and lambdoid crests are well developed. The dentition is similar to that of the typical race. The external measurements of the type (Table 1) are larger than those of the typical race, and so are the cranial measurements (Table 2).

Remarks.— Four other specimens of the new race were obtained by one of us (R.E.L.) on 14 August 1960 in the cave 2 km east of Amchite, Lebanon,

PLATE I

ABOVE, LEFT: *Myotis blythi oxygnathus* No. 6.3122, Ordoglyuk Cave, Szoplaki, Hungary. ABOVE, RIGHT: *Myotis blythi omari* No. 8.3266, Cave, 2 km east of Amchite, Lebanon. BELOW, LEFT: *Myotis myotis myotis* No. 11.3125, Ordoglyuk Cave, Szoplaki, Hungary. BELOW, RIGHT: *Myotis myotis macrocephalicus* No. 12.3265, Cave, 2 km east of Amchite, Lebanon.

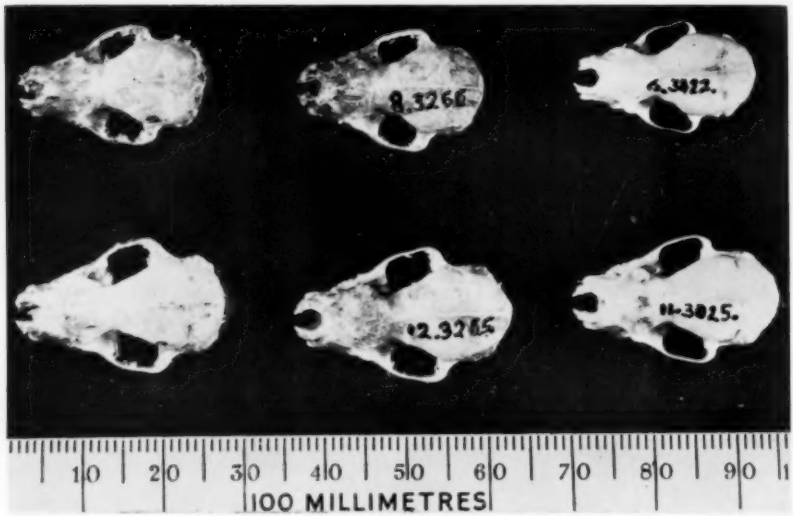

PLATE II

Dorsal views of the skulls of:

ABOVE, LEFT TO RIGHT: *Myotis blythi omari* No. 2, Tell Kalakh, Syria; *Myotis blythi omari* No. 8.3266, 2 km east of Amchite, Lebanon; *Myotis blythi oxygnathus* No. 6.3122, Ordoglyuk Cave, Szoplaki, Hungary.

BELOW, LEFT TO RIGHT: *Myotis myotis macrocephalicus* No. 3, Tell Kalakh, Syria; *Myotis myotis macrocephalicus* No. 12.3265, 2 km east of Amchite, Lebanon; *Myotis myotis myotis* No. 11.3125, Ordoglyuk Cave, Szoplaki, Hungary.

where they were caught together with two examples of *M. blythi* (Plate I). These examples display the characters of *M. m. macrocephalicus* in a marked manner. Their external and cranial measurements are similar (Tables 1, 2) and the color of the dorsal surface is uniformly pale buffy. The dusky scapular patches are present and the mid-dorsal region is slightly darkened as in the

PLATE III

Facial views, to show the ears of:

LEFT: *Myotis myotis macrocephalicus* No. 3, Tell Kalakh, Syria.

RIGHT: *Myotis blythi omari* No. 2, Tell Kalakh, Syria.

type. The specimen from Tell Kalakh, Syria, collected by David Potter on 8 December 1952 has a shorter forearm than the Lebanese examples, perhaps an individual variation. The essential characters of the new race are its larger skull and external measurements and its paler color on the back, but it must be noted that there is a good deal of individual color variation in the species and we have seen examples from Switzerland with the ventral surface pure white and nearly as pale on the back. Miller (1912) gives cranial measurements of 41 examples of *M. m. myotis* from France, Germany, Romania, Switzerland, Italy and Sardinia. In this material the condylobasal length

TABLE 3.—*External measurements (in mm) of* Myotis blythi *Tomes*

Locality	Date	Coll., No.		Length	Tail	Hind foot	Forearm	Ear	Wingspan
M. b. oxygnathus:									
San Feliu de Guixols, Spain	22 July 52	Harrison 1.1325	♀	126.5	46.5	13.6	55.9	21.7	382
"	23 July 52	2.1326	♀	113	50.8	12.5	61	21.7	384
Heviz, nr.Keszthely, Hungary	23 July 57	7.3123	♀	132	59.2	14.7	58.7	22.9	–
Abaliget Cave, Hungary	12 Apr. 57	5.3121	♀	129.3	59.2	8.9	60.7	23.5	–
Ordoglyuk Cave, Szoplaki, Hungary	15 Jan. 58	6.3122	♂	124.2	58.8	13.8	55.7	20.9	–
Zagotska Pec, Yugoslavia	12 May 57	3.2389	♂	123	55	12.5	54	20.5	–
"	"	4.2390	♀	137.5	57.5	13	56	22	–
M. b. omari:									
Derbent, Iran TYPE	–	B.M. 5.10.4.14	♂	136	61	13.5	59	26	–
"	14 May 05	B.M. 5.10.4.15	♂	–	–	14	–	22	–
Telespid, SW Iran	13 June 02	B.M. 2.10.1.5	♀	130.5	58.5	14	61.6	24	–
Nr.Resht, Iran	15 May 07	B.M. 7.7.14.6	♀	139	64	13.5	59	25	–
Tell Kalakh, Syria	8 Dec. 52	Collector's No. 2	♂	128	61	13.5	57.8	25	390
"	"	No. 1	♂	126	62	10.8	57.3	28	403
Cave, 2 km east of Amchite, Lebanon	14 Aug. 60	Harrison 9.3267	♀	135	65	15	62	25	–
"	"	8.3266	♂	139	65	16	62	24.5	–
Shiraz, Iran TYPE of *risorius*	–	B.M. 20.2.9.18	♂	138	62	14	62	26	–
Shiraz	16 June 20	B.M.25.10.4.9	♀	132	60	15	63.2	24	–
Topotype of *risorius*		B.M. 25.10.5.6	♂	125	60	14	61.7	23	–
"	14 June 20								
"	22 June 19	B.M. 20.2.9.19	♀	129	56	15	63.6	25	–
"	15 June 20	B.M. 25.10.4.8	♀	133	59	15	62.6	25	–
"	"	B.M. 25.10.4.7	♀	128	58	14	62.8	22	–
"	14 June 20	B.M. 25.10.4.6	♂	126	60	14	60.1	23	–

ranged from 22–23.6 mm. It may well prove, when more material becomes available from Asiatic Turkey and the Balkan countries, that this new form will be found to intermediate there with *M. m. myotis*.

Myotis blythi Tomes 1857, lesser mouse-eared bat:

The Syrian and Lebanese material of this species examined comprises two adult males obtained at Tell Kalakh, Syria, by David Potter on 8 December 1952, in the dungeon of Krak des Chevaliers, and an adult male and female obtained by R.E.L. in the cave 2 km east of Amchite, Lebanon.

These have been compared with the type and three other examples of *omari* and with the type and six paratypes of *risorius* in the British Museum collection. All agree closely in external and cranial dimensions (Tables 3, 4) and it seems clear that all belong to the same species. It is therefore established that

TABLE 4.—*Cranial measurements (in mm) of* Myotis blythi

Material	Greatest length	Condylobasal length	Zygomatic breadth	Breadth of braincase	Interorbital constriction	Maxillary teeth c–m^3	Mandibular teeth c–m_3	Mandible
M. b. oxygnathus:								
Harrison 1.1325	21.6	20.2	–	9.2	4.9	8.3	9.1	16.5
" 2.1326	21.3	–	12.1	8.6	4.8	8.4	9.1	15.8
" 7.3123	22.2	20.6	13.6	9.2	4.8	8.6	9.5	16.3
" 5.3121	22.1	20.8	13.9	9.6	4.9	9.2	9.7	16.4
" 6.3122	21.6	20.0	13.0	9.6	4.8	8.6	8.8	16.0
" 3.2389	21.3	19.8	13.3	9.2	4.9	8.2	8.9	16.4
" 4.2390	21.3	19.9	13.6	9.1	4.9	8.2	8.9	16.3
M. b. omari:								
B.M. 5.10.4.14	–	21.2	14.6	9.8	–	9.0	9.9	17.7
TYPE								
" 5.10.4.15	–	20.6	14.2	9.3	5.3	8.4	9.4	16.8
" 2.10.1.5	22.3	20.8	13.9	9.3	4.8	8.8	9.6	16.5
" 7.7.14.5	22.9	21.4	14.2	9.5	5.0	8.9	9.9	17.6
Elburz Mts.								
Collector's								
No. 2	22.8	21.2	14.2	9.7	4.8	9.3	9.8	17.3
No. 1	22.2	20.8	13.6	9.5	4.8	8.8	9.3	16.2
Harrison 9.3267	22.6	20.8	13.9	9.9	5.1	8.9	9.8	17
" 8.3266	22.6	21.2	14.3	9.6	4.9	9.0	9.8	17
B.M. 20.2.9.18	–	21	13.9	9.9	–	9.0	10.0	16.9
TYPE of *risorius*								
" 25.10.4.9	22.6	21	–	9.7	4.8	9.0	9.8	17.3
" 20.2.9.19	22.8	21	14.3	9.6	5.0	8.8	9.6	17
" 25.10.4.8	22.6	21	14	9.3	4.8	9.0	9.8	16.8
" 25.10.4.7	22.2	21.1	–	9.6	4.9	8.8	9.8	16.8
" 25.10.4.6	22.6	20.7	14	9.6	4.8	8.8	9.8	17
" 25.10.4.5	23.2	21.6	14.1	9.4	4.8	8.9	9.8	17.8
Shiraz								

omari and *risorius* are races of *M. blythi*, not of *M. myotis* as originally believed by Thomas. The only feature in which *omari* differs from *risorius* is in the more buffy back of the former and, since there is a good deal of individual variation in the series of the two forms examined, it is considered that this is almost certainly a matter of local and individual variation and hence that *risorius* will prove to be a synonym of the earlier named *omari*. Comparison of the cranial measurements of the Iranian, Lebanese and Syrian material with southern European material of *M. b. oxygnathus* (Table 4) clearly shows that the Middle Eastern bats have distinctly larger skulls on the average than *oxygnathus*, with slight overlap. We are therefore unable to concur with Aellen (1959) that *omari* is synonymous with *oxygnathus*, but feel that it is a distinct race with the skull averaging larger and the color of the dorsal surface averaging paler. The slightly larger skull of *omari* explains why Thomas originally considered it to be a race of *M. myotis*, since some specimens of *M. b. omari* nearly achieve the same cranial dimensions as small examples of *M. m. myotis* in Europe (cf. Tables 2, 4). Miller (1912) lists 33 specimens of *M. b. oxygnath* from Spain, Switzerland, Italy, Sardinia, Montenegro, Crete, Greece and Tunis, and in this material the condylobasal length ranged from 18.6–21.4 mm. It seems clear from this and from the material listed in Table 4 that *M. b. omari* averages distinctly larger. The largest specimens of *oxygnathus* seen are two Hungarian animals, suggesting that there may be a size cline in the species toward the larger Middle Eastern *omari*. Now that the true Middle Eastern representative of *Myotis myotis* has been discovered, the status of *omari* has become clear and it is considered that the lesser mouse-eared bats of Iran, Lebanon and Syria are all referable to this form.

ACKNOWLEDGMENTS

We wish to express our appreciation to Gordon Anckorn of Sevenoaks, who kindly made the photographic plates; to David Potter, Jeffery Harrison, G. Topal, B. Djulic, H. Lans Wachli and the late E. Flukiger, who provided some of the material on which this study was based; and to the staff of the Mammal Section of the British Museum of Natural History for their kind cooperation.

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FORMER RANGE OF THE SEA MINK

BY JOSEPH H. WATERS AND CLAYTON E. RAY

ABSTRACT: Reviewed are records of the sea mink, *Mustela macrodon*, from Casco Bay to the Bay of Fundy. This species has apparently been extinct for no less than 60 years. Details are presented of a new record from an archaeological site in Middleboro, Massachusetts, 12 miles from the nearest salt water, which extends the known range at least 125 miles southward.

In the summer of 1958 (exact date not recorded) members of the Cohannet Chapter, Massachusetts Archaeological Society, under the direction of Maurice Robbins, collected a right femur and left radius of the sea mink, *Mustela macrodon* (Prentiss). Shaft length of the femur is 61.4 mm, while that of the radius is 47.5 mm. These bones were found along with other mammal, bird, and fish remains at depths of 25 to 50 cm in and about hearths and refuse pits, in redeposited glacial material derived from the bottom of Glacial Lake Assawompsett (see Robbins, 1959: 14–15). This locality (Wapanucket #6) is an archaic Indian village site near the north shore of Assawompsett Pond (Massachusetts, Plymouth County, Town of Middleboro), 3,400 feet east of the survey marker at the mouth of the Nemasket River and 1,700 feet southwest of the survey marker on the east side of Wood Street at the corner of Vaughan Street (Fig. 1; also see Robbins, *op. cit.*).

This find represents a southerly extension of the known range of the sea mink by at least 125 miles, being the first record south of Casco Bay, Maine. Records from Campobello Island, New Brunswick, and from the regions of Frenchman's Bay and Penobscot Bay, Maine, are summarized by Manville (1942). The former may be open to question because Norton (1930) states that a skin *probably* of this species was handled at Campobello Island in 1894. He cites the range as being from Great Diamond Island, Casco Bay east to Englishman's Bay, Maine, but he feels that it also lived on the shores of western New Brunswick. Goodwin (1935) describes and illustrates a mounted specimen said to have been taken "near the Bay of Fundy about 1874." The present

record lends credence to Goodwin's unsupported statement that the sea mink "might well have been found in the salt marshes and rivers along the coast" of Connecticut.

It is not known how old the bones are. Robbins (pers. comm.) gives radiocarbon dates of charcoal from the pits as follows: U.S.G.S. sample W-363—

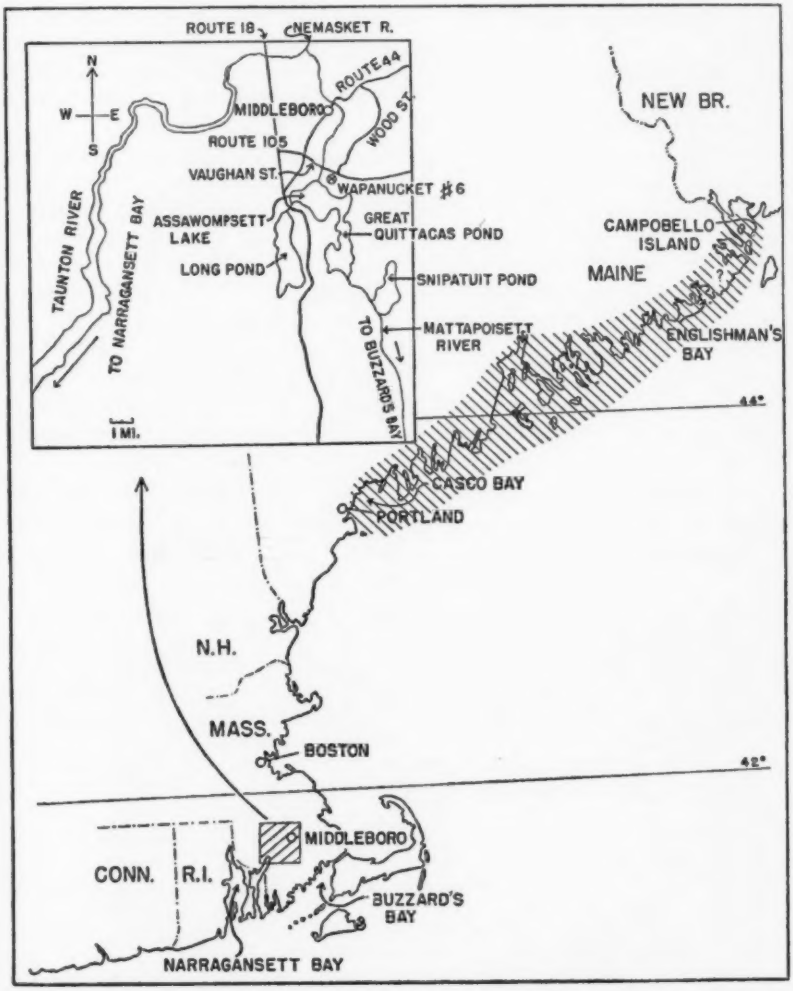

FIG. 1.—Known range of the sea mink, and locality of the find in Middleboro, Massachusetts; based in part on U.S.G.S. Survey, 1941 ed., Assawompsett Pond [*not* Lake] Quadrangle, 7.5′ (Longitude) series.

4,320 ± 250 yr.; University of Michigan sample M764—4,250 ± 300 yr.; University of Michigan sample M969—4,300 ± 250 yr. However, domestic animal bones (cow, pig, cat) were also identified from this site. These probably came from a modern refuse pit directly above the pit where the sea mink bones were found. The latter, although fire-blackened, are in excellent, firm condition. Prentiss (1903), in his original description of skull fragments in middens of the Penobscot Bay, Maine area, concluded that they were preColumbian. Loomis (1911) felt that his finds, also skeletal materials (disarticulated) from middens, were at least 200–400 years old. Since the animal has apparently been extinct for no less than 60 years, we can only conclude that our find may be anywhere from 60 to 4,300 years old.

It is not known how the animal got to this site (12 miles from the nearest salt water). Norton (*op. cit.*) feels that it was a sedentary species with a limited range, but nothing is known of its habits. It is possible that the animal reached Assawompsett Pond via either the Taunton River or the Mattapoisett River (Fig. 1). Robbins (pers. comm.) feels that both drainage systems were present when the site was occupied. It is also possible that the Indians captured the animal in either Buzzards Bay or Narragansett Bay in the summer, and returned to Assawompsett Pond with it. Robbins (*op. cit.*: 79) feels that the Indians would spend much of the summer at either of these two bays, returning with preserved fish to Assawompsett Pond in the fall before dispersing as family groups in hunting territories to the north and west, i.e., the Taunton River valley.

This find suggests the desirability of looking for remains of the sea mink elsewhere along the coast of New England in order to determine the true range of the species.

ACKNOWLEDGMENTS

We are grateful to Dr. Robbins for permission to report upon these bones, and for information on locality, radio-carbon dates, geology, and drainage of the area. The bones are now deposited in the Museum of Comparative Zoology. The identifications were made by comparison with materials in the Department of Mammals, Museum of Comparative Zoology at Harvard College, and we gratefully acknowledge the aid and cooperation of Miss Barbara Lawrence, Miss Frances Burnett, and Mr. Charles Mack.

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CUTEREBRA INFESTATION IN *PEROMYSCUS*

BY H. G. ABBOTT AND M. A. PARSONS

ABSTRACT: Details are presented of an infestation of white-footed mice by *Cuterebra*, observed in Massachusetts in 1959; an incidence of 27 per cent was noted in 214 mice captured. Cases of myiasis in *Peromyscus* are reviewed, and possible results of this parasitism are discussed.

A high incidence of skin myiasis caused by the larvae of *Cuterebra* was observed in white-footed mice, *Peromyscus leucopus*, in western Massachusetts during the summer and fall of 1959. Such infestations are by no means unique, for these parasites, commonly called bots or warbles, have been known to attack several species of mice and larger mammals. However, few instances of their occurring in *Peromyscus* have been reported during the past two decades and for this reason the following observations are presented.

Cuterebra larvae were first noted on 20 August, when one was seen emerging from the body of a white-footed mouse killed in a snap trap set on the Hawley State Forest in Hawley township, Franklin County.

One week later, a small mammal survey was initiated on the University's Mt. Toby Forest and records were kept of infested mice captured. Animals were live-trapped and marked before being released. A total of 64 *Peromyscus* was caught on four areas trapped during the period of 28 August to 1 October. Of these animals, 25 (39 per cent) contained one or more *Cuterebra* at some time during the trapping period. The number of larvae per mouse ranged from one to three. Thirteen animals contained only one larva; eight were infested with two, and four mice were hosts to three of these parasites.

During October, a fifth area on the Mt. Toby Forest was snap-trapped. Here 36 *Peromyscus* were caught but only 7 of them contained bots.

Data provided by L. P. Pringle on *Peromyscus* trapped on the Quabbin Reservation show that of 114 *Peromyscus* caught between 10 September and 28 October 1959, 27 were infested with a total of 31 *Cuterebra* larvae. Most of the infested animals, however, were caught during September.

The combined data, therefore, show that 59 mice (27.6 per cent) of the 214 animals captured were parasitized. These figures are undoubtedly a conservative indication of the degree of parasitism in these populations for they include numerous animals caught during October after some of the bots may have already emerged.

During the live-trapping survey, any larvae found protruding from the mice were removed. The large open wounds thus caused did not appear to be serious, for rapid healing was evidenced by scars subsequently seen on the bodies of recaptured animals. On only one mouse was pus noted. Another mouse, containing three larvae, was brought into the laboratory for observation. A larva was removed for photographic purposes (Plate I) and the remaining two were allowed to drop naturally. The wounds healed within one week and no apparent ill effects were experienced by the animal. Blair (1942), who found bots in chipmunks, woodland jumping mice and deer mice, observed that these wounds usually oozed pus but healed after several days. These observations are in contrast to those of certain veterinarians (Dalmat, 1943) who found that *Cuterebra* wounds in cats and dogs are slow to heal, sometimes with serious consequences.

The actual effect of *Cuterebra* on animal populations is unknown. Dalmat (1943) states that "although in a few of the reported cases of *Cuterebra* infection the larvae emerged without having inflicted any apparent hardship on the host, most investigators have observed that infected rodents were awkward and therefore easy prey for predators." He cites several instances of deleterious effects of these parasites on experimental rodents and domestic mammals. Dalmat (1942*a*) found a high percentage of emasculation in *Peromyscus*, a phenomenon which could readily affect local populations. Jameson (*in* Dalmat, 1943) found deer mice in Ontario heavily infested and the mouse population very low as compared with that of previous years. Scott and Snead (1942) suggest that these parasites contributed to a downward trend in a *Peromyscus* population in Iowa during the month of September in 1939 and 1940.

PLATE I

An anesthetized white-footed mouse infected with three *Cuterebra* larvae, one removed.

With one exception, no *Cuterebra* were found in the other species of mice, voles and shrews caught during our surveys. One of seven woodland jumping mice, *Napaeozapus insignis,* contained a single bot. It has been pointed out by Test and Test (1943) that different species of small mammals living within the same community may differ appreciably in their susceptibility to botfly attack. Their remark that such differences may be due in part to the species of *Cuterebra* involved is noteworthy, for at least three different species, *C. fontinella* (Johnson, 1930; Scott and Snead, 1942), *C. peromysci* (Dalmat, 1942*a*), and *C. angustifrons* (Dalmat, 1942*b*; Test and Test, 1943) have been found in *Peromyscus.* The *Cuterebra* responsible for the infestation which this paper reports were identified by Maurice T. James, Department of Zoology, Washington State University, who states (in correspondence): "So little has been done with the larvae of this group and, in fact, the taxonomy of the adults is in so unsatisfactory a state, that determinations beyond the generic level are for the most part impossible at present."

Because the effects of botfly larvae on *Peromyscus* populations are still largely unknown, continued reporting of infestations and more detailed records of the species of *Cuterebra* involved are desirable. This information should be of interest not only to parasitologists and mammalogists, but to forest biologists as well.

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A DRIFT-FENCE PIT TRAP THAT PRESERVES CAPTURED RODENTS

By Walter E. Howard and Elbert M. Brock

Abstract: The efficiency of lead fences of hardware cloth to direct rodents into funnel traps is discussed; a new type of pit trap that excludes birds and automatically preserves captured rodents is described. Rodents entering the trap fall through a trap door into a gallon jar containing alcohol. The pit traps primarily catch dispersing rodents; resident populations do not appear to be destroyed. Each pit trap yielded 2.5 to 45 times as many rodents as did Sherman live traps set for only one night.

It is not known when drift or lead fences of hardware cloth were first used to direct rodents into permanently set traps. Imler (1945) designed a wire cage with a "fish-trap" wire funnel that was placed along a drift fence of hardware cloth. His traps were designed to capture bullsnakes to protect duck eggs on a wildlife refuge, but they also caught live birds, rodents and other small animals. Beginning in 1948 and extending into 1952, seven traps of Imler's design were placed along 900 feet of drift fence at the U. S. Forest Service San Joaquin Experimental Range, O'Neals, California, to obtain life-span and movement data on lizards and snakes (unpublished), and to investigate the "innate" dispersal pattern of rodents (Howard, 1960). In 1953–1954, six of these traps were used to study the dispersal and homing traits of pocket gophers (Howard and Childs, 1959). The seven traps put out in 1948 were examined daily for three complete years (1949–1951). During this period they captured 2,631 vertebrates: 984 rodents, 23 other mammals, 846 birds, 679 reptiles (including marked snakes recaptured in the same and subsequent years), and 99 amphibians without counting *Hyla*.

Two objections to Imler's trap for rodent studies are that it catches birds as well as rodents and that the trap must be examined daily since it catches animals alive. Also, when captured rodents and other vertebrates were marked and put back in a trap, many were able to escape within one day. This loss was reduced with rodents and reptiles when a nest box was attached to the trap to provide a hiding place. The nest box also made it easier to retrieve captured animals. To protect the animals from too much sun, boards were placed over the trap.

To eliminate the need for daily observation and to develop a trap that would catch rodents but exclude birds, we designed a pit trap that automatically preserves all captured rodents in a gallon jar (Plate I), yet keeps out rain, leaves and sunlight. The pit-trap principle of catching rodents is an old one, and was recently reported on by Hudson and Solf (1959). Tomlinson (1960) reported on using a preservative topped with a layer of non-odorous mineral oil in a container set in the ground to trap slugs, worms, isopods and ground-dwelling insects. Our pit traps also capture a large number of invertebrates and a few reptiles. Some of the invertebrates sink to the bottom whereas others remain trapped in the mineral-oil covering.

As of June 1960, we have installed 73 pit traps in various parts of California.

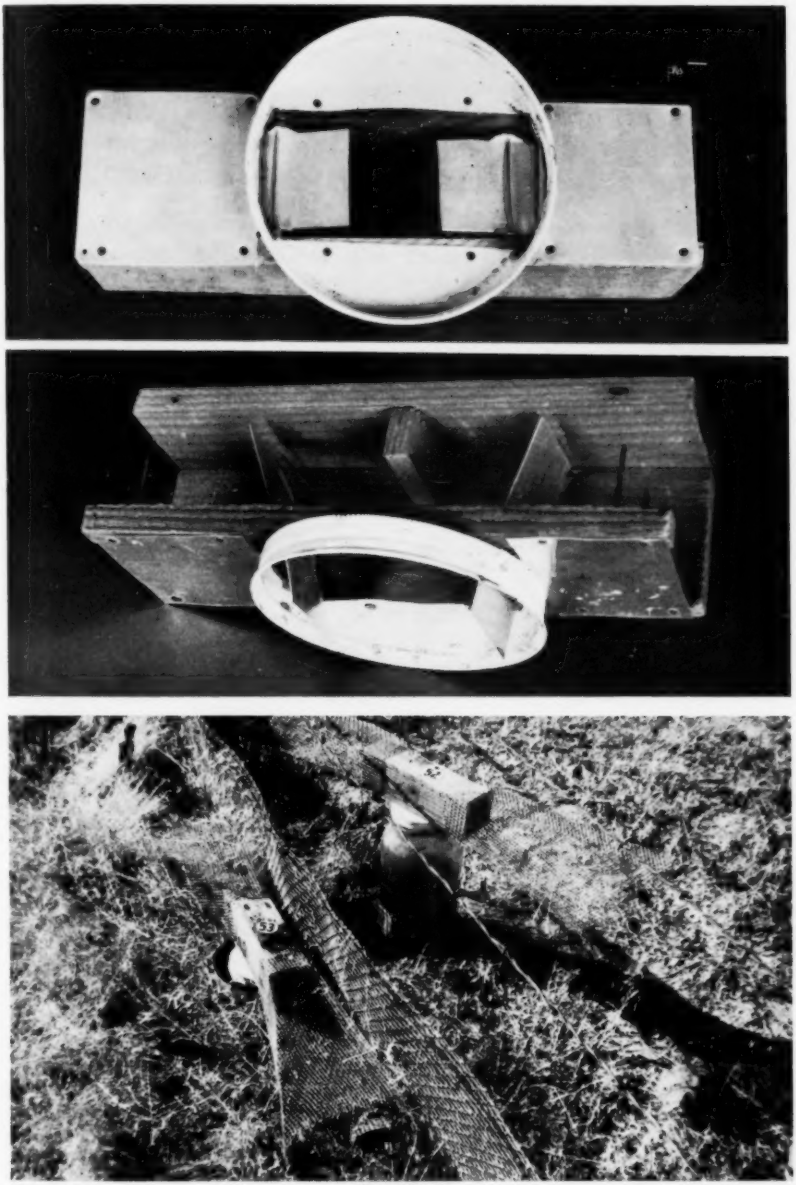

PLATE I

UPPER: Bottom view of a pit trap. CENTER: Trap with side removed. Note nail for door stop. LOWER: Two pit traps, one in place next to drift fence.

Since 1958, we have been testing different types of pit traps and various trigger mechanisms, including an open pit, push-up doors at the tunnel entrance, a second funnel to discourage animals from turning back, and the trap-door device shown in Fig. 1 and Plate I. The trap-door device worked best in both cage tests and field trials, and this is the device we are now using. The wooden tunnel is nailed or screwed to the jar top after a large opening has been cut in the jar lid.

So the soil will not cave in when the jar is removed for examination of the contents, the jar is placed in a buried metal "stove-pipe" cylinder. Two wire cross-bars are suspended through the cylinder 9¾ inches down, making it pos-

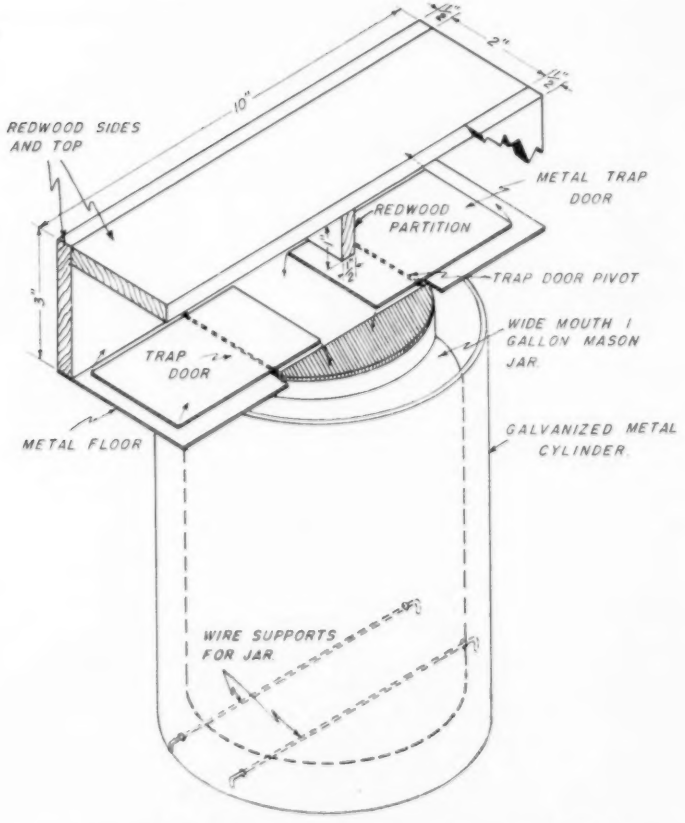

FIG. 1.—Construction design of a rodent pit trap. The top of the wide-mouth gallon jar has a hole cut in it and is attached to the sides of the wooden tunnel. The jar is placed in a metal cylinder buried in the ground.

TABLE 1.—*A comparison between the number of rodents caught per pit trap and per live trap examined on five dates in 1960 at Hopland Field Station, Hopland, California*

Date	Rodents in 24 pit traps	Rodents in 60 live traps	Captures	
			Per pit trap	Per live trap
29 Feb.	19 *Microtus* 5 *Peromyscus* 12 *Reithrodontomys* 1 *Thomomys*	2 *Microtus*	1.54	0.03
16 May	27 *Microtus* 12 *Peromyscus* 7 *Reithrodontomys* 2 *Thomomys*	4 *Microtus* 3 *Peromyscus*	2.00	0.12
14 July	76 *Microtus* 4 *Peromyscus* 12 *Reithrodontomys* 2 *Thomomys*	14 *Microtus* 2 *Peromyscus*	3.92	0.27
22 Aug.	7 *Microtus* 4 *Peromyscus* 3 *Reithrodontomys*	5 *Microtus* 7 *Peromyscus* 2 *Reithrodontomys*	0.58	0.23
8 Nov.	5 *Microtus* 7 *Peromyscus* 26 *Reithrodontomys* 2 *Thomomys*	2 *Microtus* 5 *Reithrodontomys*	1.67	0.12
TOTALS	233 of 4 species	46 of 3 species	1.94	0.15

sible to keep the jar at the proper depth so that the wooden tunnel will rest on the rim of the cylinder. It is important to make certain that the top of the jar is high enough above ground level so that it will not be flooded by rain or snow thaw. Hardware cloth funnels are used to guide the animals up and into the trap.

The most satisfactory and cheapest preservative found to date is 70 per cent denatured ethyl alcohol. Other preservatives that have been tried are 10 per cent formalin and 70 per cent methyl and isopropyl alcohol. All three alcohols are satisfactory, but denatured ethyl is the least expensive. Fusel oil, sometimes available from the wine industry, is a good cheap preservative of rodents, although the preserved animals become hard. One disadvantage of formalin is that many of the trapped rodents float, leaving part of their body exposed to insect attack, whereas animals usually sink in alcohol. Rodents left in the jars for four months were still in satisfactory condition for identifying, sexing and checking for embryos. In the field, jars are filled half full of 70 per cent alcohol and, to reduce evaporation of the preservative, covered with a ¼- to ½-inch layer of 2:1 mixture of light-weight mineral oil and hexane. Much of

the hexane may evaporate later, but the mineral oil no longer forms globules, which fail to spread over the surface. In one indoor evaporation-rate test, only 40 per cent of the preservative had evaporated after two years.

A drift-fence trap provides no direct information on the density of the adjacent rodent population; instead, it measures the "productivity" of populations, for comparison from season to season and year to year, and between different locations. Relatively few pregnant or established adults appear to be captured, and the traps do not destroy the local breeding populations. Apparently they primarily catch dispersing rodents, although this is difficult to prove by examination of captured individuals.

When the dispersal patterns of *Peromyscus maniculatus* were investigated in Michigan (Howard, 1949), all individuals making extensive (innate) dispersal movements were approaching sexual maturity for the first time, even though some were 6 months old. Those born between March and the middle of September usually became sexually active when 4½ to 7 weeks old, but the offspring born later than the middle of September usually did not mature sexually and disperse until the following March when 5 or 6 months old. Other evidence suggesting that the drift-fence pit traps catch dispersing rodents is that of 211 rodents (*Microtus, Thomomys, Perognathus, Reithrodontomys* and *Peromyscus*) caught in the drift traps and marked and released at the San Joaquin Experimental Range, only 1.4 per cent were recaptured a month or more later. This figure would surely be much larger if they were resident rodents instead of dispersers. Also, unless conventional traplines are set almost continuously, they do not catch many of these dispersers.

If pit or funnel traps are placed in pairs opposite each other along drift fences that divide two kinds of habitats, they can be used to indicate which rodent species favors which habitat. The direction of movement of rodents can also be ascertained by putting pairs of traps opposite each other along both sides of a drift fence. We hope the drift-fence pit traps will tell us whether meadow mice (*Microtus californicus*), including the breeding adults, sometimes move in large numbers from one location to set up entirely new home ranges in a new locality, as some indirect evidence now indicates. The pit traps are also being used to see if they will provide a few months' advance warning that a "mouse year" is approaching. Support for this reasoning is illustrated by the following numbers of *M. californicus* caught in seven drift traps at the San Joaquin Experimental Range: 26 in 1949, 37 in 1950, and 290 in 1951. The dispersing mice began arriving in numbers in the traps in the "mouse year" of 1951 long before they were apparent in walks through the habitat. On one day, nine were caught in a single trap. Perhaps the reason that visual observation of the habitat did not indicate so many mice is that meadow mice do not make burrows and obvious trails until they have established their home ranges; the dispersers, being trapped, had not yet had a chance to do so.

Besides their effectiveness, perhaps the most important virtues of pit traps

with a preservative are: (1) they can be left continuously set; (2) each trap can catch more than one animal; and (3) they can be examined with one visit at intervals convenient to the investigator, whereas live traps must be set the day before they are to be examined. Table 1 compares the catch of 24 pit traps examined five times with that of 60 Sherman live traps (3 × 3 × 10 inches) set for one night on the same five dates. Each pit trap yielded from 2.5 (0.58:0.23) to 45 (1.54:0.034) times as many rodents as did each live trap, indicating that once pit traps are installed, they are an efficient means of obtaining large numbers of animals per trip to the field. All of the above-mentioned traps were set within two 4-acre plots. Each plot was surrounded and bisected with hardware-cloth drift fences. All animals taken by the live traps were killed after capture.

ACKNOWLEDGMENT

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AN ELECTRIC FENCE ENCLOSURE FOR SMALL MAMMALS

BY HOWARD J. STAINS, JAMES OZMENT AND ARTHUR LIPPOLDT

ABSTRACT: A screen-wire fence topped on each side by an electric fence shows promise as a method of restricting small mammals to an area for study. Such a fence constructed around one acre should take three men less than one day to assemble, and at a cost of approximately $150, discounting labor.

A barrier or an enclosure can be utilized in population studies, behavioral observations, evaluation of census techniques, and many other types of biological investigation. Most enclosures are expensive, clumsy and relatively immovable. In the course of studying rodent populations, the authors designed

and tested a temporary, small-mammal enclosure one acre in size. The enclosure shows considerable promise, can be constructed in one day, can be easily moved from one area to another, and costs less than 20 cents per linear foot. However, it is not meant to be of a permanent nature and might be ineffective for some species.

The investigation for which this enclosure was used was financed by the National Science Foundation (Undergraduate Research Participation Program) and by the Graduate School, Southern Illinois University. Floyd Amsden, owner of Plum Thicket Farm at Sharon, Kansas, permitted the use of his land and facilities as a center for this study.

Materials.—Following is a list of materials needed to construct an enclosure around one acre of land:

Screen-wire, 425 ft of 3-ft width
Polyethylene plastic, 50 ft of 4 mil, 6 ft wide
Hand stapler and staples
Metal stakes, 18 pieces of 1 × ¼ in. strap iron, 3 ft long
Wooden stakes, 24 pieces, 1 × 2 in. by 3 ft long
Porcelain insulators, 36
Bolts with nuts, 18 of ⅜ in. diam., 4 in. long
Corks, 100 to 200, No. 10
Carpet tacks, 100 to 200
Electric fence, 850 ft of 9-gauge aluminum or 17-gauge galvanized wire
Plow, hand or tractor
Fence charger, 2 6-volt, dry-cell battery chargers

Methods.—To save time in the construction of the fence, all materials should be prepared in advance. The screen-wire should be cut in half as a width of 1.5 feet is sufficient. The polyethylene plastic should be cut in 4-inch strips, folded over the top edge of the screen-wire, and stapled in place. The plastic will act as an insulator should the fence be blown against the electric wire. Holes of 0.25-inch diameter should be drilled approximately 2 inches from the top of each metal stake. The corks should be split approximately half their distance so the electric wire can be inserted easily.

In the field, a trench 6 to 8 inches deep is ploughed around the area to be enclosed. To facilitate replacement of the dirt, the furrow should be turned inward toward the area to be enclosed. Use of a tractor provides a straighter and more even trench, thus making for a more uniform fence. A hand plow attached to the rear of a truck also will work, but the trench will not be so satisfactory. The base of the fence is buried in the trench to discourage digging by rodents. At the same time, digging the trench destroys any burrows, 6 or 8 inches below the surface of the ground, through which the animals might pass.

Next, the screen-wire is rolled out along the trench, the base placed in the

trench and bent inward. Metal stakes are driven next to and outside the fence at 50-foot intervals (Plate I). The hole in the stake should come just below the plastic strip on top of the screen-wire. Wooden stakes can be utilized to straighten the fence at points where it tends to sag and at the junction of the 50-foot strips of screen-wire.

To attach insulators to the metal stakes, a bolt is inserted through a porcelain insulator, the hole in the metal stake, the screen-wire, a second insulator, and fastened at the other end with a nut (Fig. 1A). The electric wire is unrolled around the outside of the screen fence. One end of the wire is attached to a fence charger. The wire can be most easily attached to the insulators with simple wire springs which fit around the insulator and over the wire. The wire should be twisted around the insulators at the corners because of the stress

PLATE I

Initial phase of fence construction in the field.

involved at these points. The opposite end of the wire is joined at the insulator nearest the fence charger where the wire begins. After the line is attached along the outside, another wire is strung along the inside. Both aluminum and galvanized wire are satisfactory. Each wire had good points; the galvanized wire costs one-fourth as much as the aluminum but is more difficult to handle.

At places where the electric fence is more than 1 inch from the screen, corks are inserted between the wire and screen by pushing a large carpet tack through the screen into the cork. If the electric wire is not strung too tightly, it may be easily pulled close to the screen by the corks. A wire loop should be placed at each inside corner (Fig. 1B) as this is a place of easy exit from the enclosure. Such a loop, attached to the electric wire, eliminates such escapes.

Lastly, the dirt turned in digging the trench is flipped over on the inturned screen-wire and any grass which touches the electric wire is clipped. A final check is made for any places where the electric wire may be grounded; such points are corrected by inserting corks.

Approximately 8 hours were required for three men to complete the enclosure; less than 3 hours were required to disassemble the structure. This short construction period is important in studies where as little disturbance as possible is desired. The total cost of the fence to enclose one acre was $158.36 (19 cents per foot); this included $43.00 for two fence chargers. After three trials, the fence still was usable although the polyethylene plastic needed restapling at places.

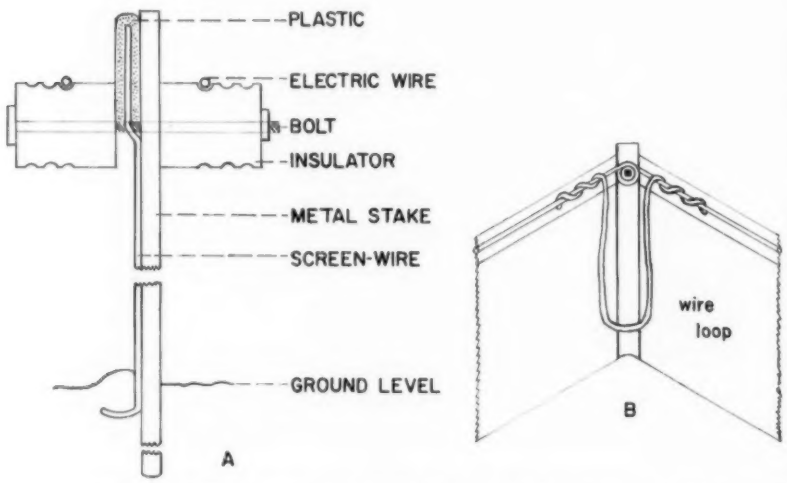

FIG. 1.—Details of electric fence. *A*, Assembly at insulator; *B*, use of wire loop at corner.

Discussion.—When the fence was tried on a small scale, a cage-reared house mouse was instantly repelled when attempting to escape. The mouse climbed the screen-wire and investigated the electric fence with his nose. It received a shock and leaped to the ground. *Peromyscus leucopus*, however, did not seem interested in climbing the fence when first released unless cornered by the investigator. When so pressed, the mice seldom received a shock and escaped at the corner of the enclosure by climbing up over the insulator. The wire loop at each corner eliminated this problem. Three *Peromyscus* remained in a small enclosure for 19, 20, and 25 days before being retrapped. Three of five wild *Mus musculus* were recaptured in 28, 28, and 29 days. Two young *Mus* were not recaptured and one, at least, may have been eaten as the animal had a scalp injury when placed in the pen. Food was placed in this small enclosure, so that its absence would not induce the mice to attempt to escape. There was no indication that wild mice attempted to dig out of the large enclosures in the period of 17 days that the three fences were tried in the field. Furthermore, no mice dug out of the small experimental enclosure in the two months that it was in operation.

Another innovation was the use of a 110-volt gasoline generator in place of a fence charger, to ascertain if mice could be killed. The thought was that, with the generator attached to the outer wire, any mice attempting to enter such an enclosed area would be killed, thus obtaining some idea of movement into the area. In no case was a kill obtained with the generator. The erratic behavior of the mice in their attempts to escape may have eliminated the chances of a good ground connection. Also, mice were escaping at the corners at this time. Such a generator should easily kill a mouse if the proper ground is obtained.

Kills were obtained in one of many experiments with fence chargers. Two *Peromyscus* were released in a small experimental enclosure on a very hot day (98°F) and forced to attempt to escape. Each mouse received a shock, jumped to the ground, ran, leaped, flailed the ground, and died in a few minutes. Death of the mice, however, was probably due to over-excitation at high temperature, conditions extremely different from those that usually exist.

Although this enclosure needs further testing to determine how long it would be effective and what array of species it might contain, its ease of construction and low cost warrant presentation of details so that others may investigate this technique further.

Dept. of Zoology, Southern Illinois Univ., Carbondale. *Received 23 January 1961.*

GENERAL NOTES

NOTES ON REPRODUCTION OF THE KOALA

Athough successful reproduction of the koala, *Phascolarctos cinereus*, in captivity is not uncommon in Australia, there has, until recently, been no record of its occurrence elsewhere. This highly specialized species is quite restricted in diet and feeds entirely on products of certain species of eucalyptus. The Australian government has, in addition, strict regulations regarding its export. These two factors account for the extreme rarity of captive koalas in other parts of the world. At present they are to be found only in the San Diego and San Francisco Zoos.

On 14 April 1959, each of the above zoos received a trio of adult koalas consisting of a male and two females. In each case, one female was carrying a pouched young on arrival. The San Diego young was first observed partly out of the pouch on 5 May 1959, and ten days later it was seen entirely free of the pouch, clinging to the ventral surface of the female. On 11 July 1959, the young koala, a female, was entirely free of the mother and nibbling eucalyptus leaves on a nearby branch.

Our single male died in September 1960, of acute leukemia, the first record of this disease for the species. Breeding, however, had occurred previously since, on 2 September 1960, movements were again noticed in the pouch of the same female. Through the succeeding days these movements became more pronounced and the pouch increased noticeably in size. At this time the San Francisco Zoo also reported an in-pounch young. In this case, also, the mother was the same that bore the original baby, a male.

On 4 November 1960, the head of the San Diego Zoo's young koala was first observed protruding from the pouch. Henceforth, partial appearances became increasingly frequent and, on 9 December 1960, the baby was first observed completely out of the pouch. Two days later it was observed feeding on eucalyptus leaves. This animal gives us the first record of a fruitful captive breeding outside of Australia.

Koalas, like other marsupials, are born in a very immature state after a gestation period of 25 to 30 days. The baby, 2 cm or less in length, migrates into the mother's pouch. Here it attaches to one of the two nipples, which swells and pulsates milk into the baby's throat. This attachment is continuous for about 5½ months, after which the young animal moves in and out of the pouch at will, riding frequently on the mother's back. At 6 to 6½ months the mother feeds predigested food from the anus. This substance has the appearance of ground eucalyptus leaves and contains the right bacterial flora required for digestion of eucalyptus leaves in the koala caecum. Weaning takes place at about 10 months of age. According to the above data, our koala was born about the middle of May, with mating taking place in mid-April. This is as expected when reversal of seasons in moving from the southern to the northern hemisphere is considered, since breeding takes place in Australia from September to January.—George H. Pournelle, *San Diego Zoological Gardens, San Diego 12, California.* *Received 23 January 1961.*

BREEDING SEASON OF THE THYLACINE

Details of all aspects of reproduction in the marsupial wolf or thylacine, *Thylacinus cynocephalus*, are incomplete and based on hearsay rather than fact. It is known that three or four young are carried in the pouch but beyond this the literature is vague and contradictory.

On account of its sheep-killing habits, this species was the subject of a government bounty from 1888–1909. I have had access to the accounts relating to the bounty payments of £1 for each adult and 10/– for each subadult. A total of 148 subadults were submitted for bounty; these are described in the accounts as "half-grown" or as "pups." Examination of the records shows that these gradings indicate animals of substantially

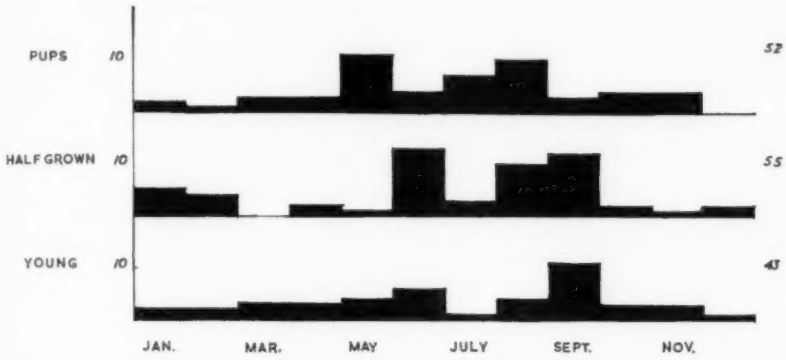

FIG. 1.—Monthly distribution of 150 pouch young of *Thylacinus cynocephalus*, based upon 148 bountied young and two other specimens. The lower histogram refers to young which were not graded into either of the above categories.

different ages. Pouch young were not included in the bounty scheme. The distribution of the young is shown in Fig. 1.

Young were taken at all months of the year with the maximum number killed in May–September. The distribution of the pups shows a peak in May and July–August and this is significantly followed by a large number of half-grown animals one month later than the earlier peaks. From the above, it may be concluded that an extended breeding season of four months takes place, or else there are two periods of activity separated from each other by two months. In either case, there is some out-of-phase breeding. An extended breeding season fits in with the present concept of dasyure breeding activity. The popular belief that December is the breeding season cannot be supported from these figures.—ERIC R. GUILER, *Dept. of Zoology, Univ. of Tasmania, Hobart. Received 9 September 1960.*

A NOTE ON OPOSSUM BEHAVIOR[1]

On 17 May 1958, two opossums, *Didelphis marsupialis*, were observed in the middle of a highway, 2 miles north and 4 miles east of Arapaho, Custer County, Oklahoma. One, a normal adult male, was attempting to mate with the other, a dead female. Despite the fact that the female's abdominal viscera were exposed, the male's penis was protracted, his forelegs gripped the female's middle, and his hind legs were around one of hers and crossed over it. During 25 minutes of continuous observation, the male made several unsuccessful attempts at copulation. His eyes opened and closed slowly at intervals.

When prodded from the rear, the male turned his head toward the observer, threatening with open mouth; but he could not be driven away from the female. His breathing was calm one minute, then became labored, then calm again. He was obviously nervous at being watched so closely.

On return to this spot after some time collecting elsewhere, the male also was dead through having been hit by a passing auto. [The time of day was not clearly stated, but indirect evidence indicated the forenoon, certainly not night.—A.N.B.]—OTIS M. KING, *Southwestern State College, Weatherford, Oklahoma. Received 15 April 1960.*

[1] I have prepared this note for Prof. King, who died suddenly on 31 July 1959. His field notes were turned over to me by Mrs. King and in them I found the substance of this note. I have followed the field notes closely, making only small changes, as is consistent with publishable English, and a few obviously necessary transitions. Because I write in Prof. King's name, I give facts only, avoiding interpretations.—ARTHUR N. BRAGG, *Univ. of Oklahoma, Norman.*

BIRTH AND EARLY DEVELOPMENT OF INDIAN HEDGEHOGS

Two species of Indian hedgehogs, *Hemiechinus auritus* and *Paraechinus micropus*, are well represented in the arid zone of Rajasthan. They are also found in Sind, Bhawalpur, Multan (Pakistan), Kutch and in the Western and Northern Uttar Pradesh. McCann (J. Bombay Nat. Hist. Soc., 39: 616, 1937) describes a single young at a birth. Prakash (*ibid.*, 53: 123, 1955) noted one to four young born at a time in *H. auritus*. Deanesly (Phil. Trans. Roy. Soc. London, B, 223: 239–276, 1934) observed one to seven young at a birth in *Erinaceus europaeus*. However, under a close watch, it was found that in both *H. auritus* and *P. micropus* the number of the young in a brood is higher than mentioned above. It appears that the irregularity in the number of young is due to the cannibalistic tendency of the mother, as immediately after delivery she consumes one or all of them.

Some pregnant females of both species were kept in a cage, 3 × 2 × 4 feet, with a thick layer of sand bedding. After a few days one *micropus* became restless and, three days later, the delivery took place. Before delivery she was kept in a separate cage, and a close watch was kept. On the first day she was restless, on the next excited, and on the day of delivery her movements became accelerated. She frequently shovelled the sand, and tried to scale the walls of the cage. This was perhaps an instinctive search for a dugout or cover for the young ones. On the morning of 19 August 1959, the expectant mother slowed down her movements and became dizzy. Finally she stopped, and adopted an arched posture. The hind limbs were raised and held wide apart. Frequently she licked the genital orifice. A few spasms passed through her frame and her head was thrown sideways, with snout extended. Finally the hind part of the body quivered and the first two young were born. After a short pause the mother became active, made a tour of the cage, came near the young and started devouring one of them voraciously. To avoid a similar fate, the other one was separated from the mother. After 8 minutes, she again laid herself flat with limbs stretched out. After a short pause she raised her body again, adopted the arched posture, and gave birth to two more young. They were immediately separated from her. Lastly, the fifth one was born. The delivery being over, the exhausted mother retreated to a corner and rested there for about 4 hours. Similar breeding behavior was observed in *H. auritus* on 25 August 1959. However, six were born in this case.

The young in both species are born with eyes closed. The eyelids being translucent, the eyeball is visible. The eyes do not open before 21 days (Plate 1). The skin of the body is tender, flesh colored and spineless. However, numerous small tubercles, hardly 0.5 mm raised, and comparable to small warts on the skin of a toad, are present on the dorsal surface only. The entire ventral surface and sides, the limbs, the snout, and the areas of the face below the eyes are devoid of these tubercles. The arrangement of the tubercles on the back of the young in both species is similar, except in the region of the head. There is a characteristic bare space in *P. micropus*. The tubercles in both species are arranged on the body more or less in transverse rows, not longitudinally. On the sides they are more numerous. The tubercle-bearing area is oval, extending between the root of the tail and the head region. On the sides this area extends up to the proximal ends of the limbs. This tubercle-bearing area is separated into the right and left sides by a clear furrow-like line over the vertebral column. Six to seven hours after birth, small, fine spines appear out of these tubercles and attain a size of 2–2.5 mm in 12 hours, and

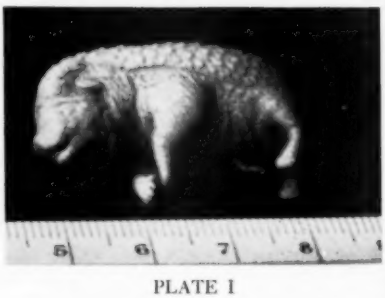

PLATE I

Newborn young *Paraechinus micropus*; scale in centimeters.

4–5 mm in 24 hours. The rate of growth of the spines is uneven. At the end of the first week they measure 9–11 mm, while at the close of the third week they are 13 mm long. At first the spines are dull pinkish-white in color. Gradually, as they grow, they become darker. Some turn gray, some completely black, and still others half-white, while a few turn completely white.

The newborn young are incapable of walking. However, they creep and crawl to locate the mother, instinctively, and start suckling shortly after birth. They begin to walk when about 12 hours old and show the capacity to roll in about a week after birth.

Hedgehogs behave at times as cannibals. The wounded, ill, invalid and weak fall easy prey to their stronger and active companions. It is curious to note that the mother, just after delivery, eats her own young.

The authors are thankful to the authorities of Birla College, Pilani, for the facilities provided them during the present investigation.—B. B. Gupta and H. L. Sharma, *Dept. of Zoology, Birla College, Pilani (Rajasthan), India.* *Received 10 September 1960.*

ADDITIONAL RECORDS OF SHREWS IN NEW MEXICO

On 10 October 1959, a female Merriam shrew, *Sorex merriami*, was captured at an elevation of approximately 8,000 ft in Red Canyon, ½ mile south and 5 miles west of Manzano, Torrance Co., New Mexico. The animal was taken by hand from beneath a slab of *Pinus ponderosa* bark in a small clearing. Prominent vegetation surrounding the clearing consists of *P. ponderosa, Pseudotsuga taxifolia, Abies concolor,* and *Quercus gambeli.* The most common mammal in the area was *Microtus mexicanus.* External measurements of the specimen are: total length 85, tail 33, hind foot 12 mm. Cranial measurements, taken as described by Findley (Univ. Kans. Publ., Mus. Nat. Hist., 9: 5, 1955), are: condylobasal length 15.1, palatal length 6.4, maxillary toothrow 6.0, cranial breadth 7.6, least interorbital breadth 3.4, maxillary breadth 4.5. This specimen represents the second known record of the Merriam shrew in New Mexico. The other was taken at Tree Springs, Sandia Mountains, Bernalillo Co. (Findley, J. Mamm., 37: 277, 1956).

The capture of a female dwarf shrew, *Sorex nanus,* in Red Canyon on the same date is worthy of mention. This animal was taken by hand from beneath a decaying log about 175 yards up the canyon from the site of capture of the Merriam shrew. Vegetation in this immediate area consists of *Populus tremuloides, P. taxifolia, A. concolor,* and *Q. gambeli.* External measurements of this specimen are: total length 92, tail 42, hind foot 10.5 mm. Cranial measurements are: condylobasal length 14.2, palatal length 5.7, maxillary toothrow 5.1, cranial breadth 7.1, least interorbital breadth 2.8, maxillary breadth 3.9. This specimen represents the fourth known record of the dwarf shrew in New Mexico. The other known specimens were taken at Gallinas Creek, Sangre de Cristo Mountains, approximately 10 miles northwest of Las Vegas, San Miguel Co. (Koster and Clothier, J. Mamm., 33: 250–251, 1952), near Capulin Ranger Station, Sandia Mountains, Sec. 33, T. 12 N, R. 5 E, Sandoval Co. (Clothier, J. Mamm., 38: 256, 1957), and 2 miles east of Ruidoso, Lincoln Co. (Findley and Poorbaugh, J. Mamm., 38: 513, 1957).

Three vagrant shrews, *Sorex vagrans,* were captured in Red Canyon the same weekend as the Merriam and dwarf shrews were taken. The vagrant shrews were trapped among rocks in the floor of the canyon.

The specimens herein reported are preserved in the University of New Mexico Collection of Vertebrates.—Clyde J. Jones, *Dept. of Biology, Univ. of New Mexico, Albuquerque.* *Received 3 January 1961.*

MYOTIS AUSTRORIPARIUS IN CENTRAL KENTUCKY

During a study of bat populations at Mammoth Cave National Park, Edmonson County, in central Kentucky, between October 1956 and March 1960, some information was obtained on *Myotis austroriparius mumfordi.* This species had not been collected previously

in central Kentucky. During this study 28 caves were investigated for bat colonies in winter and 34 in summer, in the vicinity of Mammoth Cave. *M. austroriparius* was seen in only two caves. In Dixon Cave, on the banks of the Green River in the National Park, one male was collected on 28 June 1959. It was in an active cluster of 84 male *M. sodalis*, four male and one female *M. grisescens*, and one male *M. lucifugus*. These were all clustered together over a small guano pile about 900 feet from the entrance. Another male *austroriparius* was collected here on 8 October 1959, in a cluster of about 1,500 *M. sodalis*. On both occasions, *M. austroriparius* were in an active condition.

On 19 December 1959, five female *austroriparius* were found hibernating in Bat Cave, Mammoth Cave National Park, of which two were collected and three were banded. This cave is also on the banks of the Green River, 5 miles downstream from Dixon Cave. They were found in hibernating clusters of about 1,000 *M. lucifugus*. A few *M. sodalis, Eptesicus fuscus* and *Pipistrellus subflavus* were also hibernating in the cave. On 27 March 1960, this cave was again visited. A cluster of four *austroriparius* was found close to the clusters of *lucifugus*, but they formed a cluster by themselves. Two of the bats escaped and the two that were caught were females, which were then banded. None of the three banded on 19 December was recovered during the visit on 17 March. Thus, five female *austroriparius* were seen in this cave during the winter of 1959–1960, while two others of unknown sex were also seen but not caught.

It seems that in summer, in this area, *M. austroriparius* is associated with *M. sodalis* and *M. grisescens* over guano piles. Hibernation in winter appears to be close to the places where *M. lucifugus* hibernate and they may actually be found together in the same clusters.

The Green River has its mouth in the Ohio River a short distance upriver from where *austroriparius* has been found in Hardin County, Illinois. The caves in Illinois where the species has been taken are within 3 miles of the Ohio River. Dispersion may well have been accomplished by following the Green River upstream into the cave area of central Kentucky. This species may well be a recent immigrant into this area. The bat colonies in Dixon Cave were studied carefully during three years and no *austroriparius* were seen until the fourth year of study. The only area where this species is abundant is in the cave areas of Florida (Rice, J. Mamm., 38: 15–32, 1957). If this species is moving into central Kentucky, a close watch of its populational growth might prove interesting. It would be competing for space with *M. sodalis, M. grisescens*, and *M. lucifugus*, which are quite abundant in the caves of central Kentucky.

The four *Myotis austroriparius mumfordi* which were collected in Edmonson County, Kentucky, are preserved as skins and skulls at the following places: one at the University of Illinois Museum of Natural History; two at Mammoth Cave National Park; and one at the U. S. National Museum.—John S. Hall, *Museum of Natural History and Dept. of Zoology, Univ. of Illinois, Urbana.* (*Present address Albright College, Reading, Pa.*) *Received 30 September 1960.*

OBSERVATIONS OF YOUNG KEEN BATS

While on a collecting trip in Scioto County, Ohio, I observed the young of Keen's myotis, *Myotis keeni*. The primary observations were made about 10:30 PM on 12 June 1960, in a small shelter on the shore of Roosevelt Lake, Shawnee State Forest. As far as I am aware, the young of *M. keeni* have not been previously reported.

The roof of the shelter was composed of overlapping wooden shingles over parallel wood planks running the length of the enclosure. Spaces could be seen between the planks and the overlying wooden slabs in some places. The squeaking of bats was heard in the roof of the building, and several bats were flying about in the confines of the shelter. For about half an hour the underside of the roof was inspected with a flashlight. In one spot several small bats were flying about, periodically landing and clinging to the planks. Occasionally a bat entered a space between roof planks and overlying shingles. In one instance, a

female with one young bat clinging to her left pectoral region was seen moving along the free edge of the roof plank bordering the above-mentioned space.

One adult female and two young bats were collected and kept in captivity for three days, in a small cardboard box. The manner in which the bats were collected was unusual. The two young bats fell from the ceiling onto the writer's sleeping bag, where they were found squeaking loudly. For safekeeping until morning, they were placed in a shoe. In the morning, the shoe revealed not only the two young bats, but also the adult female. One of the young was clinging to her back, the other to her left pectoral region, apparently suckling. One young bat was marked with India ink for identification. The marked bat was not observed to suckle during the two days it remained alive, but the other was seen suckling almost every time the bats were examined. The suckling bat was always seen nursing from the female's left side. The suckling bat died after three days in captivity. It is not likely that both young were the offspring of the single female. She was not fed in captivity and apparently could not produce enough milk to sustain the suckling bat for more than three days. After five days in captivity, the female was killed and preserved in formalin. The young were preserved but not measured until about five months later (both were identical). Measurements were as follows: female—79, 36, 7, 14; young—45, 14, 7, 9 mm. The three specimens are being deposited in the University of Illinois Museum of Natural History.

On the night of 22 June 1960, the shelter house was visited a second time. This time very little squeaking was heard, and only three adult bats were seen. They could not be captured and no identification was made. The space between roof plank and overlying shingles, the scene of much activity on the previous visit, appeared now to be unoccupied.—Ronald A. Brandon, *Dept. of Zoology, Univ. of Illinois, Urbana.* *Received 17 November 1960.*

ANOTHER SPOTTED BAT FROM NEW MEXICO

Another specimen of the spotted bat, *Euderma maculata*, has been collected near Aztec, San Juan County, in extreme northwest New Mexico. The animal was found clinging to a screen door 2 miles north of Aztec, about 7:00 PM on 21 September 1960, and was struck with a broom and killed. Gilbert Rogers, a high school student at Aztec, placed the specimen in rubbing alcohol and a week later took it to his teacher, J. W. McKinley, who recognized it immediately and sent it to the University of Colorado Museum, where it is now No. 7335 in the collections.

The animal is a young adult male, typically marked. Its measurements are: total length 111, tail 49, hind foot 9, ear from notch 41, tragus 12, forearm 50 mm. The skin was prepared by Lowell E. Swenson, with the wings half-spread so that all parts of both surfaces are available for close examination. Because of incomplete preservation while in alcohol, a small amount of hair slipped from the lower back on the right side. The skeleton has been preserved. The specimen has been loosely sewn to a sheet of lucite so that both sides can be examined with ease, and the whole specimen is contained in a lucite mount from which it can readily be removed for examination, but which offers protection in keeping with its rarity.

The skull is perfect: the rami of the mandible are separated at the symphysis. Comparison of the skull with published descriptions suggests that it is not exceptional.—Hugo G. Rodeck, *Univ. of Colorado Museum, Boulder.* *Received 4 November 1960.*

RECORD OF THE SPOTTED BAT FROM WYOMING

During the afternoon of 27 August 1960 a spotted bat, *Euderma maculata*, was captured in the Garland Oil Field warehouse of the Ohio Oil Co. in Byron, Big Horn County, Wyoming, by E. C. King of Lovell. King took the bat to Jan L. Holman, of the Lovell Public Schools, who identified the bat and gave me the above information.

The bat soon died and was thrown away, but was later recovered, placed in formalin, and sent to me. I attempted to relax the body, but without success, so no attempt was made to prepare a conventional study skin or to remove the skull for cleaning. Instead I spread the bat as best I could and pinned it out until it dried. The specimen is therefore a mummy with the skull still inside. The skin has slipped from part of the ventral abdominal wall and the lumbar region, but there are still indications of the spots on the back, and the diagnostic characters about the ears. The specimen has been placed in the mammal collection of the Zoology Museum at the University of Wyoming.

O. Handley, Jr. (Proc. U. S. Nat. Mus., 110: 123; 1959) states that only 16 specimens of the spotted bat were "known to be preserved in museums." None of them was from Wyoming, but Handley's map (Fig. 10) has shading over the locality where this specimen was found. Handley gives the zonal range of the spotted bat as "Lower Austral to Transition," and the upper limit of the altitudinal range as 4,045 feet. The point of capture of this specimen lies within those ranges, at about 4,020 feet elevation.—Arthur B. Mickey, *Dept. of Zoology and Physiology, Univ. of Wyoming, Laramie.* *Received 4 October 1960.*

NOTES ON *PLECOTUS PHYLLOTIS* FROM ARIZONA

Until recently, the northernmost record of *Plecotus phyllotis* was from Oak Grove Canyon, Galiuro Mountains, Graham County, Arizona (Commissaris, J. Mamm., 42: 61–65, 1961). On 10 June 1960, one of us (R.R.J.) strung up two mist nets across a stock pond on Wilbanks' Ranch (7,200 feet), 1 mile NE of Aztec Peak in the Sierra Ancha, Gila County, Arizona. The dominant trees are ponderosa pine, Douglas fir, white fir and Gambel oak. The circular pond is on the edge of a meadow bordered with quaking aspen and is approximately 15 yards in diameter. One *Plecotus phyllotis* was collected that evening. On 25 July 1960, we set the nets in the same fashion over the same pond. Between 8:30 PM and 9:45 PM we caught five big-eared bats in the nets. On the following evening Johnson again set up the nets and caught 10 big-eared bats between 8 PM and 11 PM. The wind velocity was negligible on the three evenings mentioned.

While other species of bats hit the nets from many directions, all of the big-eared bats came in from two directions and were captured at only two places in the nets. None of the bats was severely tangled in the nets, indicating that they are light fliers. Once they collided with the net, most of them did not struggle and could have escaped from the net if we had not quickly removed them. They were very docile and did not attempt to bite when handled. Their call was a low, hoarse complaint, similar to that of *Plecotus townsendi* but louder and deeper in tone. When we touched their ears while withdrawing them from the nets, the bats folded their ears along their sides in a striking fashion. This was done by lowering the distal portion of the ear downward, exposing the prominent rugae on the inner surface.

The 16 specimens, all males, show much color variation. Some are quite dark and obviously molting. On these, the hairs are charcoal gray in color, with only the distal fifth tinged with brown. In others, only the basal quarter is this color, the rest of the hair being medium brown in color.

The average and extreme measurements of 14 of the specimens are as follows: total length 114.9 (103–118); tail 50.2 (46–55); hind foot 10.8 (9–12); ear from notch 40.0 (38–43) mm. Weights of 10 individuals averaged 11.3 grams, with extremes of 10.4 and 13.2 grams.—Bruce J. Hayward, *Dept. of Zoology, Univ. of Arizona, Tucson, and* R. Roy Johnson, *Dept. of Zoology, Univ. of Kansas, Lawrence.* *Received 12 September 1960.*

PLECOTUS FROM THE PENNSYLVANIA PLEISTOCENE

Bats of the genus *Myotis* were recorded from the Frankstown Cave local fauna, a Pleistocene fissure deposit in Blair County, Pennsylvania, by O. A. Peterson (Ann. Carnegie Mus., 16 (2): 297; 1926).

Upon re-examination, all of the bat material from Frankstown Cave can be referred to the genus *Plecotus* (*Corynorhinus*). Although *Myotis* and *Plecotus* have the same lower dental formula, the single-rooted P_4 and the high, trenchant cusps are diagnostic of *Plecotus*. This material, Carnegie Museum Vertebrate Fossils no. 11171–75, consists of two right and two left mandibles, two right and two left humeri, three ulnae, two femora and a scapula, all fragmentary.

The mandibles and teeth are indistinguishable from modern specimens of *Plecotus townsendi* from West Virginia, but they cannot be assigned to species because there is no cranial material preserved in the Frankstown collection. Two North American Pleistocene forms, *P. alleghaniensis* (Gidley and Gazin) and *P. tetralophodon* (Handley) from Cumberland Cave, Maryland, and San Josecito Cave, Mexico, respectively, have been described from cranial material.

This constitutes the first record of the genus *Plecotus*, living or extinct, from Pennsylvania.—John E. Guilday, *Carnegie Museum, Pittsburgh, Pa.* *Received 5 October 1960.*

THE FUNNEL-EARED BAT IN SONORA

The funnel-eared bat, *Natalus mexicana*, has a large range in central and southern Mexico south through Central America to Colombia. The two northernmost locality records are Mojarachie (Maguarichic?) in southwestern Chihuahua, and 4 miles north of Alamos, in southern Sonora (Hall and Kelson, Mammals of North America, 1959: 153). These bats actually live well north of the above localities. I collected two males at the entrance to an old mine 13 miles southwest of Ures, Sonora (about 44 miles northeast of Hermosillo) along the Rio Sonora on 28 December 1951. This is 100 miles farther north than the Chihuahua record and 136 miles farther north than Alamos, Sonora. The new locality is 136 miles south of the Arizona border.

A rancher first showed us the abandoned mine, remarking that bats were there, and mentioned guano. Allan Phillips and I rolled aside the rocks that had fallen and blocked the entrance to the mine, and then entered to search for bats. The shaft was about head high and ran back horizontally into the hill. We explored for about 50 to 100 feet but found no bats. Since many rocks had fallen from the roof, we decided to retreat.

That evening I set a mosquito net across the entrance to the mine and waited for bats to appear. One came out at deep dusk, about 6 PM, but avoided the net and flew back into the tunnel. After a short while, I saw bats outside the mine trying to get in. They avoided my net, so I contrived a trap by placing a second net a few feet out from the first, thus making a small room in front of the mine entrance. The front net was left partly open to allow the bats to fly in toward the mine shaft. As soon as they entered, I closed the opening. Two *Natalus mexicanus* were caught in this way, one at 7:00 PM and another at 9:00 PM.

There were several other bats (possibly the same species) that repeatedly flew past the mine entrance, just skimming the ground between branches of low bushes and mesquite trees. They made no squeaking or clicking sounds. The bats easily avoided the fine silk net strung across their paths between bushes, about 8 feet from the mine entrance. In the dark I could see them fly up to the net and then away without striking. Several times I could make out the paleness of the body.

The bats which I collected were males weighing 5.2 and 5.1 grams. They had fat on the side of the body in the axillary region. One of them had testes 2 mm long and 1 mm wide.

Neither of the two specimens was molting. Both were pale and straw-colored. At the Museum of Vertebrate Zoology, University of California, I have seen similar specimens, from the southern end of Baja California, in this "gray" color phase; others from the same locality had fur that was a bright orange or reddish brown—the striking red color phase. —Harold E. Broadbooks, *Southern Illinois Univ., Alton.* *Received 19 September 1960.*

LOCALITY RECORDS AND NOTES ON WESTERN BATS

As a result of various investigations involving bats, the writer has accumulated numerous data on these mammals. Some of these data, useful at this time for distribution studies, are presented below.

Mormoops megalophylla senicula (Rehn).—Three adult females were captured in a mist net over an earthen water reservoir at the western base of Chilicotal Mountain, Big Bend National Park, Texas, on 5 August 1959. The nearest previous locality records are Fort Clark, Kinney Co., Texas (Rehn, Proc. Acad. Nat. Sci. Philadelphia, 54: 160–172, 1902), and *M. m. megalophylla* (Peters) taken 5 mi. N, 2 mi. W Patagonia, Santa Cruz Co., Arizona (Beatty, J. Mamm., 36: 290, 1955).

Macrotus californicus Baird.—Collections of this species were made at a concrete highway bridge, about 3 mi. NW Glenbar, Graham Co., Arizona, extending the known range approximately 73 mi. ESE from Superior, Pinal Co. (Allen, J. Mamm., 3: 156–162, 1922). The bats occupied deep, dark, cavelike hollows at each end of the bridge, these two roomlike structures being accessible in each case through an elevated windowlike perforation in the concrete. The species was present at this roost when it was briefly visited 27 April 1952, 25 September 1958, 25 December 1958, and 7 September 1959. In December only dead bats were present. Vandals had killed bats and started fires in the roosts, possibly influencing occupancy at that time. Numbers of *Macrotus* observed did not exceed 15 individuals, although hundreds of *Myotis velifer* and *Myotis yumanensis* had taken over one end of the bridge on September visits.

Choeronycteris mexicana Tschudi.—Two females were collected in a mine tunnel approximately 1 mi. E Lime Peak, Cochise Co., Arizona, on 2 October 1959. This spot occupies a gap in the geographical range described by Hoffmeister (Southwestern Nat., 4: 14–19, 1959).

Leptonycteris nivalis sanborni Hoffmeister.—On 1 May 1943, a group of these bats was collected by Harry J. Fletcher and Robert Herold in a natural cave, approximately 2 mi. W Tonoga Well, on the eastern slope of the Ajo Mountains, Pima Co., Arizona. The writer received a skin of a female member of the collection. He accompanied Fletcher to the cave 16 March 1946, when only *Macrotus* were present. This locality is 55 mi. SW the previously reported westernmost locality (Hoffmeister, *loc. cit.*).

Lasiurus borealis borealis (Muller).—Bailey (Animal Life of the Carlsbad Cavern, 195 p., 1928) reported that two skulls of this species were found in Carlsbad Cavern, New Mexico. On 20 February 1958 the writer collected three mummies in the "Mummy Room," a side room off the main corridor of the cavern. These and other mummies as well as skulls, taken in the cavern, are in the park collection. On 25 June 1953, a live female, containing two fetuses, was captured in the lunch room section of the cavern by one of the park personnel. The skin of this specimen is in the park collection. The park records contain a notation that a living specimen was taken in the King's Palace section of the cavern on 25 September 1951. This specimen has not been located. The writer collected a live male specimen at Rattlesnake Spring, 5 mi. SSW Carlsbad Cavern, on 7 October 1956. It was found hanging in a leafy overhang on the south side of a pear tree, 12 feet above the ground. This bat was kept in captivity for six days, when it was photographed, banded and released.

Tadarida brasiliensis mexicana (Saussure).—An immature female bat of this species was found in a moribund condition within an airplane hangar at Kingsley Air Force Base, Klamath Falls, Klamath Co., Oregon, on 7 September 1960. Previous Oregon localities where this species has been taken are Medford, Jackson Co. (Stager, J. Mamm., 26: 196, 1945) and Ashland, Jackson Co. (Jewett, J. Mamm., 36: 458–459, 1955).

Tadarida molossa (Pallas).—Three adult females were mist-netted between 10:45 and 11:15 PM, 3 August 1959, over Terlingua Creek, opposite Study Butte, Brewster Co., Texas. This is about 12 mi. WNW the previously reported Texas locality in the Chisos Mountains (Borell, J. Mamm., 20: 65–68, 1939). These specimens were banded and released.

An adult male was mist-netted at 10:45 PM, 5 August 1959, over a reservoir at the western base of Chilicotal Mountain, Big Bend National Park, Texas. This specimen was left with the park naturalist.

On 3 October 1959, an immature female was found moribund at the eastern base of the Organ Mountains on White Sands Missile Range, New Mexico. This bat was infected with rabies virus, confirmed by neutralization test.

An immature male was captured in a mist net at Dripping Springs, on the western slope of the Organ Mountains, Dona Ana Co., New Mexico, 6 October 1959.

On 12 October 1959, an immature female was captured in the Operations Building, Holloman Air Force Base, 10 mi. W Alamogordo, Otero Co., New Mexico.

An immature male was taken alive in a school classroom at Rocky Ford, Otero Co., Colorado on 13 October 1959.

Eumops perotis californicus (Merriam).—An adult male and two adult females were captured in mist nets at approximately 9:30, 10:00, and 11:30 PM, 5 August 1959, over a reservoir at the western base of Chilicotal Mountain, Big Bend National Park, Texas. This species was previously known from Texas by a specimen taken in 1903 in Langtry, Val Verde Co. (Taylor and Davis, Bull. Texas Game, Fish and Oyster Comm., 27: 1–79, 1947), about 112 mi. to the ENE, and a specimen found 12 September 1956, at Fresno Mine, Presidio Co. (Eads, J. Mamm., 38: 514, 1957), about 40 mi. W of the present locality. The females were left with the park naturalist, the male being adapted to captivity, where it is still thriving.

Eumops underwoodi sonoriensis Benson.—This species was collected by mist net over a reservoir, 3 mi. WNW Buenos Aires, Pima Co., Arizona, the same general locality where the species was reported by Hoffmeister (*loc. cit.*). A pregnant female was taken at 9:30 PM, 18 May 1959; on 22 May, between 9:30 and midnight, an adult male and a nongravid female were similarly captured. Not unlike experiences reported by Cockrum (J. Mamm., 41: 510–511, 1960), the "peeps" made by this species in flight are so intense that a sensation of ear pain was experienced by the collectors; during similar collecting circumstances in Texas, the vocal utterances of *E. perotis californicus* did not produce a similar sensation. In each species the "peeps" seemed to increase in frequency and intensity as the bat approached the pond. The three bats were adapted to captivity, using a technique described earlier (Constantine, J. Mamm., 33: 395–397, 1952) except for a greater scale of cages and food quantity. On 7 July the first female mentioned gave birth to a bare female. These two bats are still alive at this writing; the young female, unlike its mother, squeaks to attract attention, scampers across its cage to greet human visitors, is delighted to step into a gloved hand for its feeding, and squeaks complainingly when company leaves. At about one year of age this bat started making vocal sounds of a lower pitch than she had made previously. The male lived until 9 November 1959, when it was found dead in its cage with blood-filled nostrils. In the absence of the writer the caretaker froze the specimen. It showed generalized icterus, including wing and interfemoral membranes, otherwise appearing normal in gross appearance. The female captured 22 May showed little appetite 11 October 1960, when erythrocytes were present in its urine, and the bat died four days later, when it was frozen. From capture until death the coat of the male was remarkably more light reddish brown than the grayish coats of the females. The young female, born in captivity, grew a coat not unlike the adult female coat in color but markedly different from the darker, brownish coats the writer has seen in immature *E. perotis californicus*.—Denny G. Constantine, *U. S. Public Health Service, University Park, New Mexico.* *Received 9 December 1960.*

EMERGENCE TIME OF *TADARIDA* IN RELATION TO LIGHT INTENSITY

The daily activity patterns of many mammals are poorly understood. This is especially true in bats. Little is known of the life history and behavior of the pocketed free-tailed

bat, *Tadarida femorosacca*. Cockrum (J. Mamm., 37: 282–283, 1956) indicates that these bats do not leave the day roost until after sunset. Krutzsch (J. Mamm., 25: 201, 1944) reported the departure time of a California colony, observed on 17 March 1940, as 6:15 PM, but he did not state the light intensity. The present paper summarizes the results of a study on the departure time of this bat from its day roost in relation to solar radiation.

A colony of pocketed free-tailed bats has been known to day-roost (Cockrum, *op. cit.*) under the roof tiles of the chemistry building at the University of Arizona, Tucson. Observations were made from the southeast corner of this building from 26 June to 2 November 1959. These observations began before the sun had set and continued until the major group of bats had left. Times of emergence and some behavior notes were taken on each visit to the colony. These findings were compared with light intensity readings from a pyrheliometer, a horizontal surface recorder, located at the solar radiation laboratory on the campus about one mile from the site of the bat colony. Since these locations are relatively close, it is assumed that they were exposed to the same amount of radiation; therefore these values are considered comparable. The use of the pyrheliometer readings greatly reduced the error that would be caused by unfavorable weather conditions, such as clouds. All time recordings have been corrected to Mountain Standard Time.

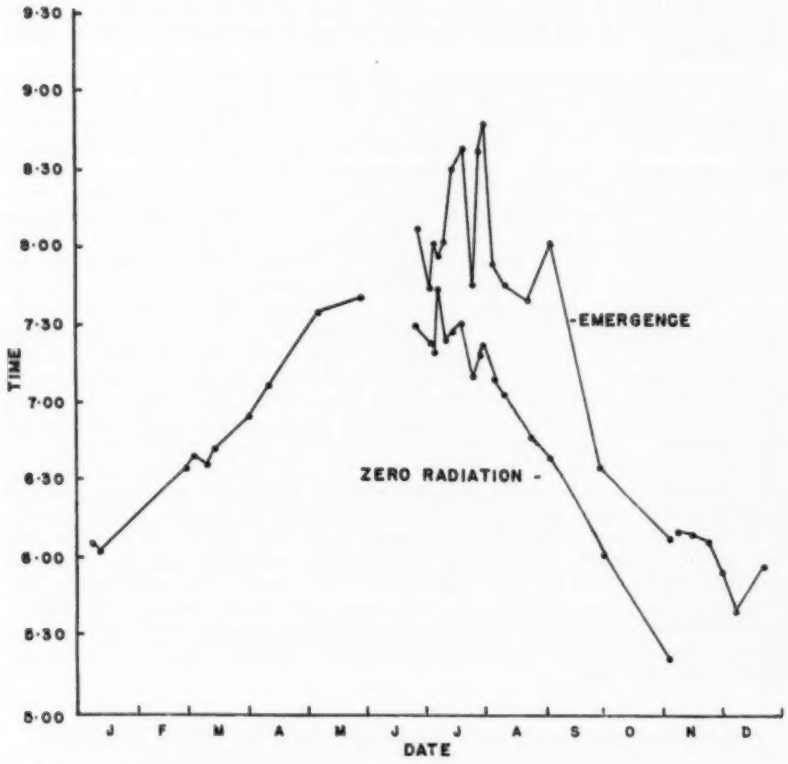

FIG. 1.—June through October—evening emergence compared with zero radiation point, 1959; November through May—evening emergence, 1954, 1955.

The time at which the light intensity reached zero langleys was plotted against the time of emergence of bats (Fig. 1). Unpublished data from observations by E. L. Cockrum and his students (1954, 1955) are also plotted on the same figure to give an approximate picture of the relative emergence pattern throughout the year.

As with the colony studied by Krutzsch, the bats kept up a constant high-pitched squeaking throughout the day, and their loud, high-pitched calls, emitted upon leaving the roost, enabled the observer to record their departure even though they could not always be clearly seen. Often one or two left the roost well in advance of the major group. These usually circled about and then returned to the roost. The bats usually began emerging by two's and three's until a steady stream of bats was formed. Up to 60 bats have been seen to leave the building at the same time. After leaving the roost, many circled around the building a few times and then headed in a southeasterly direction.

TABLE 1.—*Evening emergence of* Tadarida femorosacca *from roost, 1959*

Date	Radiation zero point	Emergence	Total radiation during day, langleys	Temperature at emergence, °F
26 June	7:29	8:07	769.8	–
2 July	7:23	7:44	643.2	90
4 July	7:17	8:01	692.7	91
7 July	7:44	7:56	—	81
10 July	7:24	8:02	721.0	98
14 July	7:27	8:30	703.0	88
19 July	7:30	8:38	742.3	92
24 July	7:10	7:45	729.4	96
27 July	7:19	8:37	—	87
31 July	7:22	8:47	722.0	83
4 Aug.	7:08	7:53	595.6	82
10 Aug.	7:03	7:46	589.8	85
24 Aug.	6:46	7:39	349.1	73
3 Sep.	6:38	8:02	640.1	–
29 Sep.	6:02	6:35	578.1	–
2 Nov.	5:20	6:08	206.4	–

The earliest emergence time noted occurred about the first of December, and this time became gradually later until the end of July. The irregular pattern observed during June and July may be the result of parturition and dependent young. This is indicated by unpublished data from embryo counts by Cockrum, which suggest birth during late June and early July. At no time were the bats seen to leave the roost before the total solar radiation reached zero. The earliest emergence time was 12 minutes after the zero point, while the latest was 85 minutes after this point. There was considerable variation between the two extremes, but the average for the summer was 45 minutes. A check of the emergence time correlated with the previous day's zero point revealed an even wider variation, indicating that emergence time is more closely related to solar radiation on the day of emergence. Temperature and the total amount of solar radiation during the day do not appear to affect emergence time (Table 1). Rain may delay the emergence, as shown by an observation on 31 July. On this date rain fell until 8:07 PM, and the bats did not leave the roost until 8:47 PM (85 minutes after the zero point had been reached). This was the latest emergence time noted during this study. The point at which the total solar radiation reaches zero appears to be an important factor in determining the emergence time of these bats, although it is certainly not the whole story.—PATRICK J. GOULD, *Dept. of Zoology, Univ. of Arizona, Tucson.* *Received 17 October 1960.*

LEOPARD FROG ATTACKS BAT

On the night of 2 August 1959, a large leopard frog, *Rana pipiens*, was discovered in the act of apparently making a meal of a small bat of the genus *Myotis*. The bat's distress cries attracted attention as we stopped to open the main gate at the Carlos Avery Game Farm near St. Paul, Minnesota. The night was moonless and the gate illuminated, attracting numerous insects and possibly insect eaters.

In our flashlight beam the frog was seen to have a solid grasp on the bat's rump. In the disturbance that followed when my son approached, the bat escaped from the frog but remained on the ground, squeaking. The frog quickly attacked again from a distance of over a foot and took the victim head first. Within a few seconds only the bat's wings and tail protruded from the frog's mouth. The wings, extending on either side of the frog's head, prevented complete ingestion immediately. About one minute later we captured the frog, which instantly spit out the dead bat. The bat had apparently suffocated, being thoroughly coated with digestive fluids.

Although food of the leopard frog consists largely of insects and spiders (Breckenridge, REPTILES AND AMPHIBIANS OF MINNESOTA, Univ. Minn. Press, 1944, p. 85) several instances of smaller bird species taken as food are on record. James Beer, in conversation, cited several instances of shrews taken by leopard frogs.

Later examination showed that the frog's stomach was empty when it attacked the bat. Brain tissue from the bat was inoculated into experimental animals, but after 26 days there was no sign of rabies in these animals.—CHARLES KINSEY, *Minnesota Division of Game and Fish, St. Paul. Received 3 November 1960.*

SYLVILAGUS CUNICULARIUS IN THE PLEISTOCENE OF MEXICO

In 1953, Prof. Antonio Barges, of Cordoba, Veracruz, Mexico, discovered the nearly complete skeleton of a glyptodon in a cavity in a silt and conglomerate cliff in the banks of Barranca Seca, approximately 3 km east of the village of Acultzingo, Veracruz, Mexico. The site of this discovery is of some interest, in that it is almost exactly at the contact of the present-day Neotropical and Nearctic faunas.

In July 1960, Prof. Barges was kind enough to take Mrs. Leora Forbes, of Fortin, Veracruz, and Miss Linda Dalquest, of Wichita Falls, Texas, to the site of his discovery. There a small collection of fossil bones was dug from the walls of the bank, and brought to Midwestern University. Most of the bones are of small mammals, but some bird bones were present and will be reported by Pierce Brodkorb, of the University of Florida. Most of the mammalian remains are post-cranial elements of opossums and rabbits, but one skull and several jaws are included.

Didelphis marsupialis.—Two well-preserved jaws, one with nearly complete dentition, of a half-grown animal.

Brachyostracon mexicanus.—Two scutes were found, and Barges donated several conjoined scutes from his first find; he also supplied a series of excellent photos of his specimen, which now is largely lost. Both photographs and the scutes at hand resemble the original figures and description of this species (Brown, Bull. Am. Mus. Nat. Hist., 31: 167–177, 1912).

Sylvilagus cf. floridanus.—A palate with the first molar has been compared with *Sylvilagus cunicularius*, *S. brasiliensis*, *S. floridanus connectens*, and *S. f. orizabae*. Resemblance to *Sylvilagus floridanus* seems closest. I am indebted to E. Raymond Hall, of the University of Kansas, for the loan of the comparative material, all of which came from near the site of the fossil deposit.

Sylvilagus cunicularius.—A skull of a large rabbit was embedded in a silty matrix. The basicranial area is broken and missing, and a very hard matrix covers the palatal area. A part of the matrix was removed, enough to show that at least some of the teeth are missing.

Two right lower jaws, one without teeth, are also present, and are of a size to match the skull.

These fossils are much too large for *Sylvilagus floridanus*, and are about the size of *Lepus californicus*. However, when compared with *Lepus*, numerous differences in detail are apparent. When compared with a skull of *Sylvilagus cunicularius*, No. 30749, Univ. Kansas Mus. Nat. Hist., from 3 km west of Acultzingo, collected 5 December 1948, the resemblance is very close. The greatest difference is in the width, posteriorly, of rostrum and nasals. The fossil exceeds both the specimen of *S. cunicularius* and all available jack rabbits in this respect. However, it seems likely that the condition could be equaled if a large enough series of skulls of *Sylvilagus cunicularius* were examined. So far as I am aware, this is the first fossil record for this common Mexican rabbit.

Of the four species of mammals represented in the collection, little is known of the habitat preferences of the glyptodon. *Didelphis* and *Sylvilagus floridanus* occur in both the tropical and temperate faunas of the area today. *Sylvilagus cunicularius* is typically a representative of the temperate zone, and ranges today in the hills above, and perhaps even down to the site of, the fossil deposit. The presence of this species east of Acultzingo indicates that the area was at least not more tropical at the time the fossils were deposited than it is today.—WALTER W. DALQUEST, *Midwestern Univ., Wichita Falls, Texas.* *Received 23 January 1961.*

A NEW METHOD OF PREPARING LAGOMORPH SKINS

The method described here produces a compact, durable skin in less time than conventional methods. Specimens prepared by the new method have been used conveniently in comparisons with older specimens. All parts of the pelage can be observed as readily as in conventional skins.

Standard external measurements and weight are ascertained and a complete label is written and tied to the right hind leg above the heel. The distance between the label and the double overhand knot tied in the strings before attaching the label should be 2 inches or more, so that the entire label extends beyond the rear of the finished specimen and is clearly visible without picking up the specimen when the specimen lies in a tray. The label is tied with a firm square knot or surgeon's knot (Fig. 1*A*), tightly enough that there will be no risk of the string slipping off over the heel in preparation. Then the specimen is skinned in the standard way through a mid-ventral abdominal incision.

A piece of corrugated pasteboard or other material is cut to the measured length of the head and body and to a width to suit the specimen (Fig. 1*B*). One end of the piece is cut to a shape to accommodate the head and neck, and the corners are rounded slightly on the other end. The pasteboard form is then wrapped by rolling it in a thin sheet of cotton batting until moderately and firmly padded. The skin is then slipped onto the cotton-wrapped "body." A heavy, white, cotton thread 3 feet in length is threaded in a strong needle and left doubled. A large overhand knot is tied in the ends of the thread. The ears are sewn in place by passing the needle through the fold at the middle of one ear from within the ear, then into the cotton of the nape of the "body" and out the opposite side, then through the other ear (Fig. 1*C*). The threads are pulled snugly, a large overhand knot is tied within the ear last sewed, and the threads are severed beyond the knot. The skin of the nape region should not be folded in such a way as to obscure any part of the nape, and the ears should be sewn to either side rather than together at the midline, so that the nape is clearly visible between the ears. If necessary to see beneath the ears, the threads holding them in place can be severed after the specimen is dry, care being taken not to break the skin by bending the ears too far. The specimen is turned over. A 12-inch length of monel wire is placed within the skin of the tail where the vertebrae were removed and is thrust through the tip of the tail so that half its length extends beyond the tail. The non-protruding end of the wire is imbedded securely in the cotton "body" (Fig.

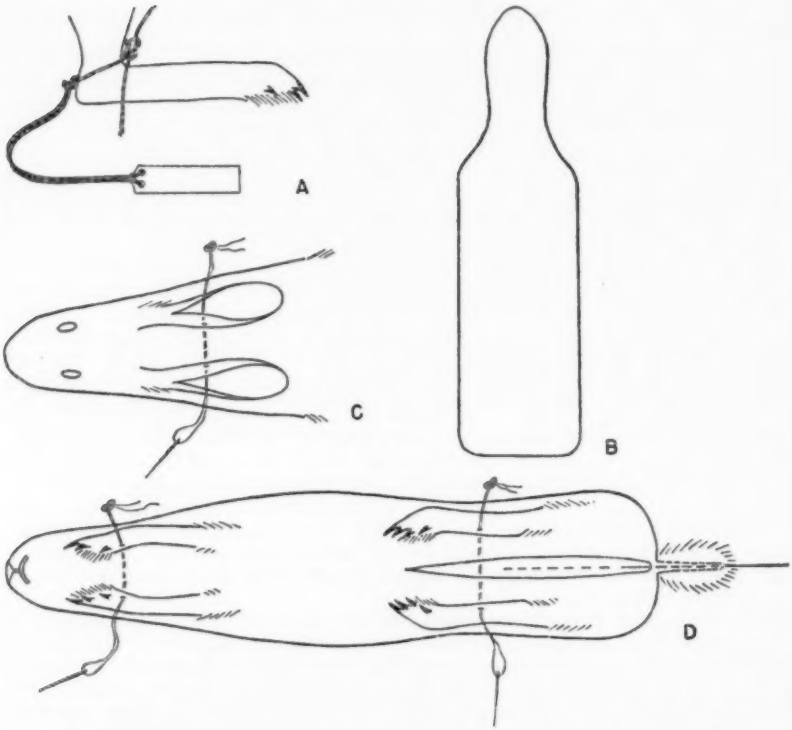

FIG. 1.—Sketches of four steps in the preparation of a specimen. *A*, The attachment of the label, showing knots used and the greater than usual length of string. *B*, The shape of the pasteboard form used. *C*, The method of sewing ears in place. *D*, The placement of wire in the tail and the method of sewing feet in place. Drawings are by Walter Holmquist.

1*D*) and the tail with enclosed wire is bent ventrally beneath the "body." Then the protruding length of wire is imbedded firmly in the cotton. The feet are sewn in place with the plantar surfaces turned medially. Both forefeet and hind feet are sewn firmly in place against the "body." The threads pass through the middle of a foot from lateral to medial side just below the metapodial bones, then deeply into the cotton wrapping, out the opposite side and through the middle of the opposite foot but from medial to lateral side. The feet are pulled firmly into place, another overhand knot is tied to hold them, and the threads are severed beyond the last knot tied. No wires or padding are placed in the feet or legs. If necessary, the ventral incision and the mouth are sewn shut. The specimen is dried in the usual way.

This method of preparation requires less than three-fourths of the time usually required. Specimens prepared by the new method require less than two-thirds of the storage space needed for specimens prepared by other methods.—SYDNEY ANDERSON, *Dept. of Mammalogy, The American Museum of Natural History, New York 24, N. Y.* *Received 9 January 1961.*

REINGESTION IN THE MOUNTAIN BEAVER

Most investigations on reingestion by mammals have been concerned with rabbits and hares, as summarized by Lechleitner (J. Mamm., 38: 481–485, 1957). This phenomenon has been reported in *Crocidura* by Booth (Proc. Zool. Soc. London, 126: 167–170, 1956). It was first suspected as occurring in the mountain beaver, *Aplodontia rufa*, when three captives were observed for a month in the summer of 1958, at 7,000 feet altitude near Huntington Lake, California.

The mountain beaver has six or seven alternating periods of rest and activity daily (Ingles, Am. Midl. Nat., 61: 419–423, 1959). Unless disturbed, the pattern of activity concerned with defecation and reingestion is always the same. Upon emerging from a rest period, an animal proceeds immediately to its fecal pile. Here it assumes a squatting position with its short tail and partly everted large intestine projecting upward between the hind legs (Plate I). As each of the oblong hard pellets is passed, the animal takes the pellet into its mouth and tosses it onto the fecal pile. Normally, defecation requires from 2 to 5 minutes. It is always interrupted once or more, however, when the animal raises its head, which continues to nod, as it chews vigorously for several seconds. After tossing pellets onto its pile, one animal was observed to reach out and retrieve the last discarded pellet and to chew it. Another animal, disturbed during defecation, ate a pellet from the pile when it returned.

Three adult female mountain beaver, captured the first week of July 1959, were killed and the contents of their digestive tracts examined. All three had both the large, soft pellets and the much more numerous, smaller, hard pellets in the large intestine. Counts of the pellets, forward from the anus, in one animal showed 13 hard, 1 soft, 23 hard, 1 soft, followed by an amorphous mass. Another animal had 23 hard, 1 soft, 10 hard, 1 soft, and amorphous material. Each soft pellet was roughly four times the volume of a hard pellet. The hard pellets were dark green or brown; the soft pellets were composed of light

PLATE I

A mountain beaver defecating and reingesting.

green, finely macerated material. In the stomach of one animal were unmistakable clumps of soft pellet material mixed with the harsher, dark green stomach contents.

The function served by reingestion is not known. It has been suggested (Crowcroft, LIFE OF THE SHREW, Stellar Press, 1957) that in *Sorex* it may be connected with the conservation and use of vitamins, proteins and trace elements. It has been described in various rodents by Harder (Verh. Deut. Zool. in Mainz, 95–109, 1949), who suggests a relationship to cellulose digestion. It seems probable that reingestion may occur more widely among mammals than is ordinarily supposed.—LLOYD G. INGLES, *Fresno State College, Fresno, California. Received 26 September 1960.*

CRANIAL ASYMMETRY IN THE POCKET GOPHER

In a collection of 1,162 plains pocket gophers, *Geomys bursarius*, trapped in connection with a study of this animal's reproductive cycle, only one specimen was recorded as having a dental abnormality. This individual, a female approximately one year old, lacked the right upper incisor. The gopher was taken on 19 March 1960, 10 miles south of La Salle, Weld County, Colorado. Because the skull showed a number of abnormalities probably resulting from the lack of a complete upper set of incisors, some interesting questions concerning functional morphology were raised.

The skull was bilaterally asymmetrical owing to a number of deviations from the pattern of the "normal" skull. Although a socket was present for the missing incisor, no tooth material was present in the socket. The socket was constricted posteriorly and ended adjacent to the anteriormost part of the zygomatic plate instead of at the normal point of termination at the posterior base of the plate. On the right side of the skull, much of the lacrymal bone was heavily eroded. The cause of this erosion was not determined. The following other cranial characters were noted: right zygomatic arch inclined abnormally sharply ventrad; posterior end of zygomatic portion of right maxillary with pronounced expansion where it joins the jugal; right infraorbital canal larger than the left; zygomatic portion of right maxillary merging with rostrum farther forward than does left maxillary; as compared to corresponding bone on the left side of skull, right zygomatic plate broader and thicker with anterior and posterior surfaces rough instead of smooth; as viewed dorsally, skull anterior to interorbital constriction inclined to the right; left upper incisor inclined sharply to the right; right jugal more strongly bowed laterad than left jugal.

Many of the above morphological characteristics may have been influenced by the way in which the masseter muscles were used by the animal during gnawing. These large muscles originate on the side of the rostrum and the zygomatic plate and arch, and insert on the mandible. Such attachments enable the muscles to serve as powerful elevators of the mandible. With the right upper incisor absent, the lower jaw was probably shifted toward the left when the animal was gnawing, in order to bring the two lower incisors in opposition to the single upper incisor. This offsetting of the lower jaw would have meant that the masseter muscles on one side of the skull pulled against the zygomatic arches on which they originated at a different angle than did the masseter muscles on the opposite side. In addition, the distances between the origins and insertions of the masseter muscles of one side would not have been the same as those on the other side, resulting in unequal forces being exerted on their origins. Certain skull characteristics listed above may have been developed in compensation for this offsetting of the mandible during gnawing. It can be seen, for example, that with the right zygomatic arch inclined more sharply ventrad than the left arch, the masseter muscles of the opposing sides of the skull could act against their origins with the same force and at the same angle when the mandible was offset to the left. The inclination of the rostrum and the left upper incisor to the right served to bring this tooth nearer the midline of the skull. Although this is clearly an advantageous development, it is difficult to envision its causes. It appears probable, however, that the

pronounced asymmetry of the skull arose primarily as a result of osteological compensation for bilaterally unequal forces exerted by the masseter muscles during gnawing.

The remaining upper incisor, as a consequence of taking all of the wear resulting from occlusion with the two lower incisors, was abnormally heavily worn, but this had seemingly not markedly disrupted normal use of the incisors. According to Miller (J. Mamm., 39: 380–385, 1958) the rate of growth of the incisors of pocket gophers does not depend on the use or degree of wear of the teeth, but is fairly constant in a given individual. Some minor change in the gnawing habits of the animal under discussion was probably necessary to keep the single upper incisor from sustaining so much wear as to disrupt normal occlusion to the extent that effective gnawing could no longer be accomplished.—TERRY A. VAUGHAN, *Experiment Station, Colorado State Univ., Fort Collins.* *Received 13 December 1960.*

[Technical Journal Article S.S. 687, Colorado Agricultural Experiment Station.]

THE BREEDING OF *DIPODOMYS DESERTI* IN THE LABORATORY

Attempts at breeding kangaroo rats in the laboratory have been comparatively unsuccessful because of their solitary disposition. Bailey (N. Am. Fauna 53, 1931) induced *Dipodomys spectabilis* to breed, but after successful mating the female wounded the male so badly that he died. Day, Egoscue and Woodbury (Science, 124: 485, 1956) successfully bred *D. ordi* after enlarging the cages and altering their techniques to fit the ecological and behavioral patterns of kangaroo rats. Chew (J. Mamm., 39: 597, 1958) successfully bred *D. merriami* in an outdoor cage in which desert conditions were simulated. I likewise have been able to induce several breedings of the desert kangaroo rat, *D. deserti*, in the laboratory.

A vigorous pair of kangaroo rats was allowed the freedom of a large room approximately 6×8 meters. Desert soil and sand, to a depth of several centimeters on the floor, served for cleaning and digging. Open cages, with nesting chambers, were provided in opposite corners of this laboratory for nest sites. The temperature of the room fluctuated between 60 and 70°F daily. Light entered by two northern exposures. The animals were fed a combination ration of sunflower seeds and rolled oats daily, and lettuce was introduced into the cages every other day. The two animals were released in this laboratory and after fiercely fighting for several hours became tolerant of one another. Strange animals caged with the pair were mutilated or killed. Although copulation was not observed in the first instance, a litter of four was born approximately 5 months after caging the pair together. Successive breedings of the same pair resulted in seven litters of young.

No definitive courtship period exists in *D. deserti* because of their intensive aggressive behavior. A short precopulatory period, when the two sexes are quite compatible, is immediately related to the sexual act. The female does not tolerate the advances of the male until the proper condition of estrus has occurred. During this period she presents herself to the male. Quite frequently she drags her genital region in the sand as if cleaning herself. In seeking out the male, she first faces him and then turns her genital region to him. The male noses her genital organs and occasionally bites the base of her tail. This behavior continues until the male effects copulation.

In copulation, the male mounts the female posteriorly, grasping her pelvic region tightly with his forelimbs. He also holds the skin of her neck with his teeth. The female digs nervously in the sand with her front feet during copulation, but makes no attempt to escape. The actual sex act varies in length from one to several minutes and movements are relatively slow. The male rocks clumsily back and forth, using his tail as a brace which prevents him from falling over backwards. This motion brings the scrotum in contact with the ground and causes the scrotal area to become irritated and red. During the height of the breeding season, numbers of males examined in the field showed this condition. Throughout the copulatory procedure the female voices a purring or growling sound. The male is silent.

After separation, the two animals vigorously kick sand in short swift strokes, drumming and thumping the ground with their hind feet in an apparent high state of excitement. The next several minutes are spent in examination and cleaning of their genitalia. Tail grooming, the pulling of their long tails through their forelimbs and mouth, is one of the most important parts of their grooming. This is true not only after copulation, but in their daily grooming activities. After coitus, examination revealed that the glans of the male was extending from the prepuce, was red with irritation and was covered with sand; the female's swollen vaginal orifice was also red and covered with sand.

A few hours after copulation, a gelatinous plug develops in the vaginal orifice of the female, and she no longer tolerates the advances of the male. My observations of laboratory animals and kangaroo rats examined in the field indicate that there are two morphological types of vaginal plugs, a "copulation plug," appearing in the vaginal orifice about 12 to 15 hours after copulation, and a more transitory plug, which I have called a "secretory plug," appearing in the vaginae of nulliparous females during estrus. The copulation plug is durable and persists for several days. The secretory plug is less durable and can be removed easily. Copulation plugs generally are darker in color and tightly fill the vaginal orifice. Secretory plugs are composed of mucus, sloughed tissue and blood. Both types of plugs have a gelatinous texture and also include grains of sand. The differences between the plugs may be due to secretions from the male reproductive system in copulation plugs, while secretions from the female genital tract alone are responsible for the secretory plug of nulliparous females. Females constantly press their genital organs into the sand of their cages during estrus and after coitus, and this behavior probably explains the presence of the sand in the plugs. The secretory plug apparently is the sloughed lining of the internal genital tract. Occasionally, large sheets of tissue form casts which outline the internal vaginal tract. The sloughed tissue, with mucus and blood, often protrudes from the vaginae of laboratory animals as regression of the orifice after estrus occurs. The presence of either type of plug in field animals can be assumed to indicate reproductive activity.

In the seven litters bred in my laboratory, one contained two individuals; four litters contained three; one litter contained four; and one litter contained five young. These seven litters, producing 23 young kangaroo rats, had a mean of 3.29 young per adult female, with a mode of 3.

Observed gestational periods ranged from 29 to approximately 32 days. Precise determinations, in four litters, indicated that one litter was born 29 days after copulation and three litters were born 30 days after copulation.

Trial breedings of *D. deserti* in smaller areas have met with no success. The female of this species kills males or other females, if the animals are confined in an area which is too small. In larger areas, the male can escape the female's fierce aggressiveness during diestrus, and is available when she becomes receptive to copulation during estrus. Chew's success with *D. merriami* was attributed to a selective use of females during the proper estrus periods. He believed that size of the caging was not too important. Because *D. deserti* is more solitary than *D. merriami*, breeding cannot be induced except in large areas. Desert kangaroo rats, unlike Merriam's kangaroo rats, will not remain together, except in rare cases, or in the case of litter mates. Only in exceptional cases, have I been able to cage animals together without the resulting death of one or both of them. It appears that cage size, then, may be an important factor in the laboratory breeding of *D. deserti*. Although pairs of *D. merriami* were caged under similar conditions to those for *D. deserti*, breeding was not induced. It may be that temperature fluctuation, as suggested by Chew, is important in the breeding of *D. merriami*.

I kept one pair of desert kangaroo rats in a large confined space for over two years. Although the male constantly was scarred from frequent fighting with the female, he managed to escape to protected areas of the large breeding cages and was then always available, during the periods of estrus, when the female was receptive.—BERNARD B. BUTTERWORTH, *Dept. of Biology, Univ. of Wichita, Wichita, Kansas.* *Received 13 January 1961.*

UNUSUAL ABUNDANCE OF *PEROMYSCUS* AT GOTHIC, COLORADO

During the months of July to September 1956, the deer mouse, *Peromyscus maniculatus*, was unusually abundant in the region of Gothic, Gunnison County, Colorado. This area is the site of the Rocky Mountain Biological Laboratory and is described by Findley and Negus (J. Mamm., 34: 235–239, 1953). The elevation at the laboratory is about 9,500 feet. The valley slopes are covered primarily by Engelmann spruce (*Picea engelmanni*) and alpine fir (*Abies lasiocarpa*). On the lower slopes and valley floor are scattered groups of aspen (*Populus tremuloides*) and willow. Much of the valley floor is covered with meadow grass (*Festuca thurberi*).

The unusual abundance of *Peromyscus maniculatus* during the summer is shown by the fact that, during the evening of 2 July, 21 individuals were trapped in one building during a 4-hour period, using only one trap which was reset after each capture. As many as 40 mice were observed crossing the road in front of an automobile, while driving in the evening the 5.8 miles from Gothic to Crested Butte.

Trapping nine plots about 100 feet square, between 4 July and 28 July in the *Festuca* habitats, yielded 69 animals in 143 trap-nights. Of these, 49 were *Peromyscus maniculatus*, 9 were *Microtus longicaudus*, 5 were *Eutamias minimus*, 4 were *Clethrionomys gapperi*, with one *Zapus princeps* and one *Sorex*. On 1 August, under the direction of Robert K. Enders, Swarthmore College, traplines were set 2 miles north of Gothic on the North American Census of Small Mammals pattern. These two lines, in a meadow grass habitat, were 1,000 feet long with ten trapping stations of three traps each spaced at 100-foot intervals. The lines were run for three nights and yielded 130 animals, the majority of these being *Peromyscus*.

TABLE 1.—*Captures of* Peromyscus maniculatus *on two NACSM traplines (total 60 traps) at Gothic, Colorado, 1956*

Date	Pelage type	Males	Females	Total	Trap success, %
5 Sept.	Adult	10	10	20	66.6
	Subadult	11	9	20	
6 Sept.	Adult	3	5	8	63.3
	Subadult	11	19	30	
7 Sept.	Adult	1	2	3	31.6
	Subadult	10	6	16	
Total		46	51	97	

On 4 September these two lines were retrapped, again for a period of three nights (Table 1). In a total of 180 trap-nights, 97 *Peromyscus maniculatus* were taken. These included 46 males and 51 females. Thirty-two males and 34 females showed subadult pelage. No juveniles were taken. In addition, one *Microtus montanus* female with 6 embryos was taken, along with two *Sorex cinereus*. No embryos were found among the *Peromyscus*.

Trapping along the edge of the Engelmann spruce–alpine fir forest suggested that little penetration of this habitat by the *Peromyscus* occurred. However, they appeared to be extremely abundant in all other habitats. They were so abundant around the camp in the evening that two of us could not keep six traps properly emptied and over 40 animals were taken in these traps in an hour and a half.—ROBERT H. CATLETT, *Dept. of Zoology, Univ. of California, Davis,* AND ROBERT Z. BROWN, *Dept. of Zoology, Colorado College, Colorado Springs.* *Received 23 January 1961.*

HOMING BEHAVIOR OF DEER MICE AND POCKET MICE

In March 1956 I tested the homing of deer mice, *Peromyscus maniculatus*, and pocket mice, *Perognathus parvus*, in the desert of northern Oregon. The experiments were all too brief, but since nothing has been published on homing of *Perognathus* and *Peromyscus* in this habitat, the data may be useful.

The study plot was about 2 miles west of Irrigon, Umatilla County, Oregon. Low, scrubby sagebrush about 2 feet high and spaced about 15 feet apart was the most conspicuous plant on the gently rolling plain. Much of the ground between the bushes was barren sand, but there were no dunes. A narrow road ran in a north-south direction along the west side of the area trapped. On each side of the road dense thickets of tumbleweeds were piled up in windrows against barbed wire fences. There were a few kangaroo rat burrows in one corner of the plot, but no *Dipodomys* were captured.

Forty live-traps were set in a grid covering about 2 acres (400 × 200 feet). The traps were aligned in four parallel rows, each row with 10 traps spaced about 45 feet apart. The first row was set along the fence by the road. The distance between the first and second rows was 150 feet, but the other two were spaced at 45-foot intervals. Whole corn was used as bait. Individual mice were toe-clipped for identification.

The plot was trapped on 15, 22, 23 and 26 March 1956. The traps were checked each morning by 10 AM and the mice taken away and released for homing tests. Eight mice captured on 15 March were taken by car on a rather circuitous route ½ mile south, then east along another road, and finally were carried about 300 feet north to a point about ½ mile ESE of the study plot. On 22 March an additional eight mice were transported this same route and released ¼ mile ESE of the plot. A third group of eight mice was taken ¼ mile north by car, then carried 100 feet east of the road. In each case the mice were released individually at 30-foot intervals along a line that faced the study plot. This system was intended to minimize the effect of crowding at the release point.

Perognathus parvus.—Table 1 summarizes the results of live-trapping. Thirteen male pocket mice were tested for homing ability. Four of these were transferred ½ mile ESE on 15 March, but were not recaptured. On 22 March four were carried ¼ mile ESE. One of these, a large adult male, was recaptured on the study area the following morning. Six mice (including the recaptured one) were released due north ¼ mile on 23 March. None was caught on the home plot three days later.

One of the surprising discoveries was the extremely unbalanced sex ratio: 23 of 24 pocket mice were males. This predominance of males was not a local situation, for on Blalock Island, 7 miles southwest of the study area, I caught 28 males and only 1 female in 40 live traps on 25 March and 1 April.

The species seems to be inactive during the winter in this area, since I caught no pocket mice in 44 trap-nights between 25 and 28 February. Presumably the mice were hibernating. When they do come out in the spring, it is the males that emerge from their burrows first.

Peromyscus maniculatus.—Ten deer mice were caught on the plot (Table 1). Eight were males and two females. The latter were lactating adults. Two of the males were old adults, five were young adults, and one was a juvenile.

Nine deer mice had their homing ability tested. Four released ½ mile ESE failed to return. In the second test three males and one female were released ¼ mile to the ESE; one young adult male was recaptured within 24 hours. In the third experiment two young adult males (including the one that had already returned ¼ mile) were released ¼ mile north. Both mice were recaptured on the plot three days later. One of these mice thus was successful in finding his way home from two different directions, traveling ¼ mile in each case.

Discussion.—Success in homing may be influenced by such factors as temperament, territoriality, size of home range, and density of population. The pocket mice were distinctly pugnacious. They squeaked loudly and fought each other fiercely when placed

TABLE 1.—*Homing data on 13 pocket mice* (Perognathus parvus) *and 9 deer mice* (Peromyscus maniculatus). *Data were obtained from live-trapping near Irrigon, Oregon, on a 2-acre plot, 15–26 March 1956. All mice were removed from plot and taken to release points on day caught*

Date	*Perognathus*					*Peromyscus*					Release point	Time to return, days
	Captures			Recaptures		Captures			Recaptures			
	♂	♀	Total	♂	♀	♂	♀	Total	♂	♀		
15 March	4	0	4	0	0	3	1	4	0	0	½ mi. ESE	. . .
22 March	4	0	4	0	0	3	1	4	0	0	¼ mi. ESE	. . .
23 March	6	0	6	1	0	2	0	2	1	0	¼ mi. N	1 or less
26 March	10	1	11	0	0	3	0	3	2	0	. . .	1 or less 3 or less
Totals:	24	1	25	1	0	11	2	13	3	0		

together in the same live trap, and often squeaked and tried to bite when handled. The deer mice, on the other hand, were calm and placid. Half a dozen or more in the same live trap would huddle quietly in a heap. They seldom struggled to escape.

In the pocket mice, vigorous defense of territory might go along with their pugnacity. The one mouse that did get back was an unusually large adult male. His large size and dominance over other mice may well have helped him return home in his cross-country journey of ¼ mile.

The size of a mouse's home range obviously should be considered in any homing experiment. An animal with a large range would have the advantage of a large target area. The greatest diameters of the home ranges of five adult male *Perognathus parvus*, which I caught 4 to 10 times each at Rocky Flat in northern Yakima County in Washington, averaged 485 feet. The range in greatest diameters was 196 to 974 feet. Eight adult *Peromyscus maniculatus* at Rocky Flat, with an average of 23 captures apiece, had home ranges with greatest diameters averaging 583 (342–761) feet. Thus it appears that a pocket mouse or deer mouse would almost always be well outside its home range if carried ¼ mile away.

The very abundance of the pocket mice in the study area may have prevented them from returning home. It would seem that the more frequent the encounters with other mice (especially antagonistic ones) the more difficult it would be for one of them to return home over strange ground.—HAROLD E. BROADBOOKS, *Southern Illinois Univ., Alton. Received 12 September 1960.*

REITHRODONTOMYS MONTANUS GRISEUS IN MISSOURI

On 9 October 1960, an adult female plains harvest mouse, *Reithrodontomys montanus*, was trapped by Claudine F. Long in an Ozarkian, grassy area at a place 7 miles northwest of Jane, McDonald County, Missouri. This specimen (KU 84079) resembles specimens of *R. m. griseus* from eastern Kansas in having dark upper parts, darker along the midline, and two dark spots (one above the other) on each pinna; in external and cranial dimensions it also resembles this subspecies. It is assigned to *griseus*, and constitutes, to my knowledge, the first record of occurrence of *R. montanus* in Missouri. From approximately 100 miles westward, Blair (Am. Midl. Nat., 2: 118, 1939) recorded *griseus* from a place 3 miles east of Wainwright, Muskogee County, Oklahoma; Cockrum (Univ. Kansas Publ., Mus. Nat. Hist., 7: 168–169, 1952) recorded the subspecies from 2½ miles north of Toronto, Woodson County, Kansas, approximately 125 miles northwestward. Five immature *Sigmodon hispidus* were trapped in the same meadow as was the specimen from Missouri. External measurements of this specimen are: total length 127, length of tail vertebrae 53, length of hind foot 14, and length of ear (from notch) 12 mm.

Additionally, it is noteworthy that a male (KU 81948) of *R. m. griseus* was obtained on 26 March 1960, by R. R. Patterson, at a place 2 miles north of Peoria, Ottawa County, in extreme northeastern Oklahoma, from which area this subspecies has not been recorded previously.—Charles A. Long, *Museum of Natural History, Univ. of Kansas, Lawrence. Received 9 December 1960.*

STRANDED KILLER WHALE IN THE BAHAMAS

Because records of the killer whale, *Orcinus orca*, off the southeastern United States are few, the stranding of one of these animals on Great Abaco Island, Bahamas, is reported. The record is of additional interest since this cetacean only rarely beaches itself. The writer is indebted to Mr. and Mrs. John W. Coolidge, Cambridge, Massachusetts, for the data pertaining to the stranding, including eight good photographs of the skull in various aspects, isolated teeth, the cervical bloc, and ribs (Plate I).

The animal stranded alive on the eastern shore of Man O'War Cay, Great Abaco Island, sometime in June 1960. There were several open wounds in the tail region and the whale was followed inshore by a number of large sharks, the appearance of the latter at this spot being considered unusual in itself. The animal is reported as having been about 20 feet long, with a large dorsal fin. The skull is described as being about 4 feet long and the teeth about 5 inches in length with about 3 inches imbedded in the gum. The teeth numbered 14 pairs in the upper jaw and the same (with some question) in the lower jaw.

It is clear from the photographs of the skull that it belongs to *Orcinus orca* and the few other data are all compatible with this identification. Although most authorities state that *Orcinus* has from 10 to 13 pairs of teeth in each jaw, according to Tomilin (Zveri SSSR i prilezhashchikh stran. IX. Kitoobraznyye. Acad. Sci. USSR, Moscow: 1–756, 1957), 14 pairs are occasionally encountered.

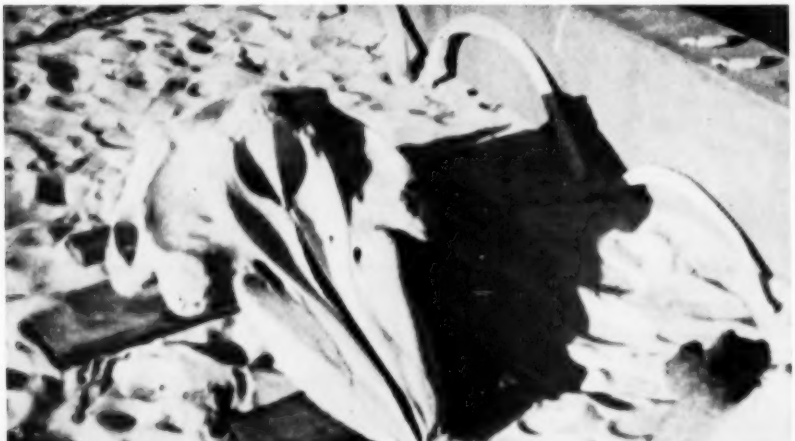

PLATE I

Skull and isolated teeth and ribs of *Orcinus orca* stranded on Great Abaco Island, Bahamas, in June 1960. (*Photo by J. W. Coolidge.*)

Moore (Am. Midl. Nat., 49: 117–158, 1953) gives Florida records for the killer whale. In addition to two strandings, he lists five sightings of this animal, all in the Gulf Stream off the Florida east coast. According to Moore's informants, this animal is not often encountered in these waters. Caldwell, Layne and Siebenaler (Quart. J. Fla. Acad. Sci., 19: 189–196, 1956) report an additional Florida stranding, and Gunter (U. S. F. W. S., Fish. Bull. 89: 543–551, 1954) reports a sighting off Port Aransas, Texas. On the occasion of the present stranding, Man O'War Cay inhabitants stated that the animal was completely unknown to them.

In addition to the one reported here, strandings on the east coast of North America are as follows (of single individuals unless otherwise noted): New Melbourne, Trinity Bay, Nfld., 27 April 1957, 19 or more individuals (Dearden, Canad. Field-Nat., 72: 166–167, 1958); Chapel Arm, Trinity Bay, Nfld., 9 June 1955 (Sergeant and Fisher, J. Fish. Res. Bd. Canada, 14: 83–115, 1957); Economy, Minas Basin, N. S., 4 Jan. 1950 (*ibid.*); Eastport, Me., March 1902, 2 individuals (True, Proc. U.S. Nat. Mus., 27: 227–230, 1904); Tenant's Harbor, Me., 14 Dec. 1957 (Mairs and Scattergood, Maine Field Nat., 15: 111–113, 1959); Harpswell, Me., 14 Nov. 1904 (Norton, Proc. Portland Soc. Nat. Hist., 4: 101, 1930); Barnegat, N. J., Jan. 1909 (True, Science, 29: 790–791, 1909); Wildwood Crest, N. J., 27 Jan. 1941 (Ulmer, Not. Nat., 83: 1–5, 1941); Summerland Key, Fla., about March 1948 (Moore, *op. cit.*); Everglades, Fla., Dec. 1921 (*ibid.*); 6 miles E of East Pass, Okaloosa Co., Fla., May 1956 (Caldwell, Layne and Siebenaler, *op. cit.*).

In these 12 strandings the whales have come ashore alive in four cases. In one case the whale was first noted dead in the surf but may have come ashore alive earlier. In the remaining seven cases this information is not available.—Richard H. Backus, *Woods Hole Oceanographic Inst., Woods Hole, Massachusetts.* *Received 25 January 1961.*

[Contribution No. 1085 from the Woods Hole Oceanographic Institution.]

WHALES WITHOUT FLUKES OR FLIPPERS

In a recent paper (Pacific Nat., 1 (1), 1959) I mentioned the cases of two whales with missing flukes. One, a humpback whale, *Megaptera novaeangliae*, had lost one fluke; the other, a gray whale, *Eschrichtius glaucus*, had lost both. Yet both had survived and were able to swim, the humpback normally. The gray whale, however, turned on its side to take advantage of the lateral flattening of the tail and to retain the vertical motion of swimming in relation to gravity.

In October 1958 a large, scattered aggregation of blue whales, *Sibbaldus musculus*, moved into the San Francisco-Monterey area of California, apparently from the southwest. There were 26 captured by the five catcher-boats of the two whaling stations working out of Richmond, in the northern part of San Francisco Bay. Two of these blue whales flensed at the Golden Gate Fishery had mutilated flukes. Some months later the manager, Robert Casebeer, drew them (Fig. 1) as he remembered them. The captains of the boats which captured the whales had noted nothing abnormal in the swimming behavior of either. Yet, of course, their speed might have been impaired and actually made capture easier. These whalers do not crop the flukes for towing to the station.

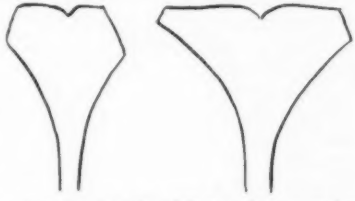

Fig. 1.—Mutilated flukes of blue whales brought in at Golden Gate Fishery, Richmond, California, in 1958.

In October 1960 I again visited the whaling stations at Richmond, and obtained the following information from Hermann Foland, owner of the fishery and captain of the catcher-boat *Sioux City*, and from Harold Ridle, gunner on the same boat. All through the 1959 season they had seen a large humpback whale with the left fluke missing, but failed to kill it after

repeated attempts. It ranged during the six months from Point Sur, 20 miles south of Monterey, north 140 miles to Pt. Reyes, above San Francisco. At times it was seen in company with other humpbacks, some of which were shot. This whale was not seen during the 1960 season, despite more intense hunting, and it was presumed to have died or changed its summer feeding grounds. The whalers called it "Old Half-track."

While rereading Scammon's classic "Marine mammals of northwestern North America" (1874), I came across a passage which applies here. He described the capture of a right whale, *Eubalaena sieboldi*, by "spading" it across the "small" of the peduncle on the tail, with a blubber spade, thus cutting the tendons to the flukes. Though "the flukes become entirely useless, still the animal hardly slackens speed perceptibly, showing, evidently, that its pectorals are powerful propellers" (p. 69). Although I believe it is possible for a flipper to row a whale forward to some extent, no one, so far as I know, has seen a whale propelling itself even slowly with its flippers alone, much less at a rapid rate—nor even a porpoise in an oceanarium.

The Eskimos in the old days hamstrung the bowheads, *Balaena mysticetus*, that they captured. Perhaps some observations on the swimming actions of a whale so crippled will come to light in some traveler's journal, or even in the field—for the Eskimos are still whaling. French whalers—to a greater extent than the American or British—in the early 19th century also hamstrung large whales as part of their regular technique of capture.

N. A. Mackintosh refers to a blue whale without a flipper. He recounts in a footnote (Disc. Rep., 22: 215, 1942) that "Commander S. A. Brooke (in the *Sourabaya*, 1934–35) watched the swimming of a pair of blue whales while he was on a catcher . . . chasing them. . . . The male was caught, [and] the right flipper was found to be completely missing, the shoulder being healed and covered with blubber . . . but it was noted that the whale's swimming and control had apparently been unaffected."

The flipper is extended often as the whale makes an arc at the surface to breathe, and thus must function as a horizontal vane, helping change direction up and down. It can also help in turning by unilateral twisting, or braking, action. The whale's body has considerably more flexibility than is apparent from viewing a dead carcass; it can twist and turn easily and through a great range to change direction, without aid of flippers. No whale has lost its flippers through evolution. They must be of fundamental importance in swimming. They are small, it is true, in the ziphiids, but they are enormous in the humpback whale.

All this has considerable importance in the light of work that has been done by the British, under J. Gray and D. A. Parry, and by the Americans under sponsorship of the Navy, on the swimming dynamics of the porpoise. It also shows how adaptive is the organism, to fundamental changes in structure, with appropriate changes in function.—RAYMOND M. GILMORE, *San Diego Museum of Natural History, San Diego, California.* *Received 7 September 1960.*

RECENT RECORD OF WOLF IN OHIO

On 8 January 1943, a male timber wolf, weighing 65 pounds, was killed by Joe Andraeta near Augusta, Carroll County, Ohio. This wolf was the last and largest of a pack of six animals using for refuge an 80-acre *Crataegus* thicket on the farm of John Reed. Approximately 100 sheep were killed by the wolves. Five of the wolves were shot and retrieved; the sixth, shot and wounded, was thought to have died in the thicket but was never found.

Of the five animals retrieved, pelts of two were sold to fur dealers, two were made into rugs, and one was mounted. Only the mounted specimen could be located in 1953. It was found at Canton, Ohio, in an attic of Joe Andraeta, who donated the specimen to the Ohio State Museum.

The mounted specimen was shipped, for identification, to Stanley P. Young, of the U. S. Fish and Wildlife Service, together with a statement of the circumstances of its capture. Mr. Young advised us (*in litt.*) that "Examination of the specimen reveals that undoubtedly

it is a wolf. . . . On a geographical basis . . . the specimen you have is *Canis lupus lycaon*. . . . I am inclined to agree . . . those wolves reported in Carroll County, Ohio, in January 1943, could have come from Canada. . . . Under certain conditions wolves have no hesitancy in taking long journeys across frozen streams or lakes. In fact it is such winter conditions as this that often result in wolves turning up in areas where they had previously been believed to be extinct."

H. N. Burke, meteorologist at the Cleveland Hopkins Airport, stated (*in litt.*) that temperatures in northern Ohio were near normal during the winter of 1942–43, and that "There are usually open stretches of water in the lake, and the winter in question would hardly be one that you would suspect would cause the lake to freeze entirely across." Raymond D. Schofield, of the Michigan Department of Conservation, advised us (*in litt.*) that wolves are now present in Michigan only on the Upper Peninsula, and the last one recorded killed on the Lower Peninsula was in 1907.

Inquiries of the zoological parks at Cincinnati and Cleveland, Ohio, and at Pittsburgh, Pennsylvania, and of the McCleary wolf kennels at Kane, Pennsylvania, disclosed no evidence that any wolves had escaped. It seems improbable that six large wolves had been transported into Ohio from the north, or had been raised from pups before their escape, without its being known in the neighborhood. With no direct evidence on the matter, their manner of entry into Ohio must remain a question.

We wish to express our gratitude to E. H. Dustman and the Ohio Cooperative Wildlife Research Unit for aid in assembling the information in this note.—PAUL A. STEWART, *U. S. Fish and Wildlife Service, Gadsden, Alabama,* AND NORMAN C. NEGUS, *Dept. of Zoology, Tulane Univ., New Orleans, Louisiana.* *Received 29 September 1960.*

FURTHER NORTHERN EXTENSION OF THE HOG-NOSED SKUNK

While enroute to Hoover Dam from Kingman, Arizona, on 8 October 1960, I found the crushed remains of a hog-nosed skunk, *Conepatus mesoleucus*, on the highway ½ mile south of the Temple Bar junction. The region is a wide, gentle-sloping detrital plain, sparsely vegetated with desert shrubs, mainly creosote brush and a few cacti—a place one would hardly expect to find skunks.

In February 1956, a specimen of this species was collected about 16 miles southeast of Kingman by William F. Musgrove (Musgrove and Hoffmeister, J. Mamm., 38: 414, 1957). At that time the capture marked the most northwesterly occurrence of the species, while the present record extends the range of *Conepatus* about 73 miles farther north and much nearer to the Colorado River barrier.

The site of the present record was in an area where the animal could not have found suitable shelter nor an abundance of food, so without question under propitious conditions the species will reach canyon areas slightly farther north, and the range extension will be halted by the Colorado River.—LAURENCE M. HUEY, *San Diego Society of Natural History, Balboa Park, San Diego, California.* *Received 18 January 1961.*

GESTATION PERIOD IN THE SPOTTED SKUNK

There appears to be no published account concerning the gestation period in the genus *Spilogale*. Therefore, the following occurrence is of interest.

On 19 May 1960, a spotted skunk, *Spilogale putorius leucoparia*, trapped 120 days earlier along the Rio Grande River at a point 5 mi. N Las Cruces, Dona Ana Co., New Mexico, gave birth to at least two young. Since capture the skunk had been kept in a rabies escape-proofed cage situated 5½ feet above the floor in a rabies escape-proofed building, which had contained no other spotted skunks. This history would certainly eliminate the possibility of contact with other members of the species following capture. The newborn skunks had apparently fallen through the mesh floor of the cage. One of the

young skunks, a female, was found alive in the cement floor gutter immediately adjacent to the cage. Another newborn female was recovered from the drain trap a few inches away. This skunk was dead. Before being preserved in formalin it weighed 11.4 grams. A fresh, undried blood vessel protruded from its ½-inch umbilical cord. It is possible that additional newborn skunks were lost down the drain.

The two posterior mammary gland nipples of the mother were enlarged as was the adjacent mammary tissue of these and the six other glands. Her vagina was swollen and extended. The live newborn female was placed with the adult, and nursing followed. This young skunk survived with its mother until 4 July 1960, when it was found dead. It had appeared to be choking on 1 July, but symptoms had subsided. Its brain, submaxillary salivary glands, kidneys, spleen and liver were tested for rabies by the mouse inoculation test and found negative. This incident provides evidence of a gestation period in this species of at least 120 days, approximately double the gestation period in *Mephitis*.—DENNY G. CONSTANTINE, *U. S. Public Health Service, University Park, New Mexico.* *Received 9 December 1960.*

AN UNUSUAL INCISOR IN *MEPHITIS MEPHITIS*

Although the dental formulas of mephitines are usually given as $i\frac{3}{3}$, $c\frac{1}{1}$, $p\frac{3}{3}$, $m\frac{1}{2}$ for *Mephitis* and *Spilogale*, and $i\frac{3}{3}$, $c\frac{1}{1}$, $p\frac{2}{3}$, $m\frac{1}{2}$ for *Conepatus*, there is often variation in the number of premolars in any of these genera (Van Gelder, Bull. Amer. Mus. Nat. Hist., 117: 246, 1959). To our knowledge, variation in the number of incisors in this subfamily is unrecorded, and the following information may be of interest. A subadult-young adult (basisphenoid suture fused but evident) specimen of *Mephitis mephitis holzneri*, No. 8428 Los Angeles County Museum, from ½ mile west of Crenshaw Boulevard on Stocker Boulevard, Baldwin Hills,

PLATE I

The incisors of *Mephitis mephitis holzneri*, L.A.C.M. No. 8428, showing the unusual divided incisor.

Los Angeles County, California, has three normal incisors in the left premaxilla but only two in the right. Although i^3 on the right side is normal, the single medial right incisor is divided distally for 2 mm and functions as would two normal incisors, each portion of the bifurcate tooth occluding, at least in part, with the appropriate lower incisor (Plate I).

In addition to the abnormality of the incisor, this specimen, which is probably a male, lacks the first upper premolar on each side, a condition which is usual in *Conepatus* but which occurs in less than 5 per cent of more than 500 Pacific Coast *Mephitis* that we have examined.—Richard G. Van Gelder, *The American Museum of Natural History, New York 24, N. Y.*, and Charles A. McLaughlin, *Los Angeles County Museum, Los Angeles 7, California.* *Received 26 September 1960.*

UNDERGROUND CONCEALMENT AS A METHOD OF PREDATION

While studying behavior of Uinta ground squirrels, *Citellus armatus*, in 1960, I made incidental observations on predatory activity of badgers, *Taxidea taxus*, in an area 20 miles northeast of Logan, Utah.

Ordinarily, badgers dig into ground squirrel burrows to capture both active and hibernating animals (Seton, Lives of Game Animals, 2: 292, 1926). The aboveground evidence of this digging is a mound of loose soil beside an enlarged burrow entrance. I often saw this evidence in the study area but considered it largely ineffective as a means of capturing active ground squirrels. This was because the study area was pervaded with burrows and entrances which offered ample opportunity for the ground squirrels to escape.

On the morning of 14 July, I saw badger diggings which differed from the usual type. Loose soil partially blocked the enlarged entrance of the ground squirrel burrow. With the aid of a flashlight, I looked beyond the soil barricade and saw nothing. By chance, I flashed the light into an undisturbed entrance to the same burrow 8 feet from the undisturbed entrance. There was a badger a few inches below the surface. During the next few minutes the badger moved back and forth underground between the two entrances, peering at me through the undisturbed entrance and then through the partially blocked passage of the enlarged entrance. I opened the burrow and found that the badger had enlarged it to a point 4 inches below the surface of the undisturbed entrance and then partially blocked the enlarged entrance from inside (Fig. 1).

On the mornings of 17 and 20 July, I again observed enlarged entrances and partially blocked burrows. I again found the same digging pattern and badger behavior. In each of the three cases, the badger and burrow were different. During August and September, after the ground squirrels were in hibernation, I continued to investigate badger diggings but saw only the usual open holes dug deep into the burrows.

The two digging patterns by badgers may have represented different methods of capturing ground squirrels. In the usual pattern, that of digging open holes deep into the burrows, badgers dug in active pursuit of ground squirrels either to corner them when they were active or raid their nests when they were hibernating. In the other pattern, that of digging

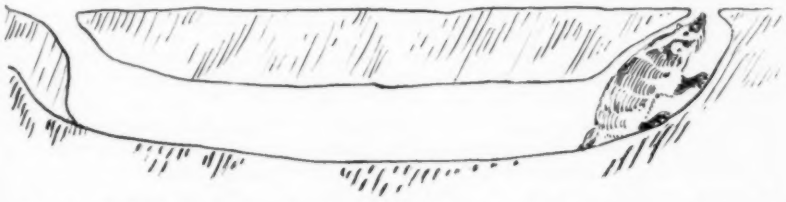

Fig. 1.—Badger in an enlarged ground squirrel burrow, with entrance at left partially blocked from inside.

below the surface and partially blocking the entrance, badgers may not have been digging in active pursuit of ground squirrels. It appeared to me that this digging pattern functioned as concealment for the badger as evidenced by the soil barricade and the failure to dig through the undisturbed burrow entrance. By remaining concealed during the day, immediately below either of the two entrances, the badgers were in an excellent position to catch ground squirrels that ran into the burrow. Ground squirrel behavior in June and July made them easy prey to this type of predation. During this time they relaxed territorial defense and moved about more freely. When frightened, they dashed into the nearest burrow and possibly into the waiting jaws of a badger. The situation is similar to what Snead and Hendrickson (J. Mamm., 23: 380–391, 1942) call intermittent co-use of a burrow, successful for badgers in catching ground squirrels. Although I did not actually see predation occur, on the three mornings I observed the "ambush" method I lost a total of five ground squirrels that carried field identification marks: one adult female and four young. In each of the three cases, the badger activity was near the center of the home ranges of the missing ground squirrels.—David F. Balph, *Dept. Wildl. Mgt., Utah State Univ., Logan.* *Received 13 January 1961.*

[Supported by Utah State University Division of University Research.]

TOLERANCE AMONG NOCTURNAL WOODLAND CREATURES

A dozen feet from my dining room window I feed a few of the wild animals that live in our neighborhood and prowl at night. I have been doing this for the past three summers. The animals cannot see me for I have no light in the room. Two 40-watt lights illuminate their pans of food.

This summer I have one female raccoon, *Procyon lotor,* that I raised from 5 inches. She left her home at 9 months and did not return, to my knowledge, for 15 months. Then she brought four "teen-age" coons with her.

There are two gray foxes, *Urocyon cinereoargenteus,* that have a den on the hill 1,000 feet back of our house, and any number of odd-sized opossums, *Didelphis marsupialis.* All pay a call nightly. In addition I have two Siamese cats, *Felis domestica,* that watch the wild animals feed. One hides in a cellar window behind the foundation planting.

The fox usually arrives first. The 'possum lumbers up the terrace next. The fox grabs a piece of bread or meat scrap and retires under a pine tree. The 'possum then helps himself. One evening, when the fox came before dark, I watched one Siamese cat chase him three times to the road, 75 feet away.

When the 'coon arrives, either alone or with her cubs, she chases both the fox and the cat. One evening she chased both these animals away and when she returned the 'possum was eating out of her dish. She walked up and joined him; both continued to eat and no words were exchanged between the two. Neither seemed to object to the other's presence. The 'coon growls at the cats, but wastes no words on the fox. I have never heard the fox bark at any of these animals.

One must conclude that the 'coon and 'possum are compatible and that the fox and 'possum are reasonably so, in that they don't fight each other. The 'coon will not tolerate the fox. The fox gives ground to all three—'coon, cat and 'possum, in that order. The 'coon is always boss, whether alone or with her young. Two years ago I saw her brother chase the fox 200 feet before turning around.

Since recording the above observations, I have acquired three skunks, *Mephitis mephitis.* Both 'possum and 'coon seem to have no fear. In fact both either eat with the skunk or snap at him. It was amazing to see the 'coon and skunk eating from the same dish. Twice I thought I was in for trouble. Once the 'coon walked away; another time the skunk retreated, but not until after he had turned his back on the 'coon. I believe the skunk would have made trouble except that he didn't want to contaminate the food. Once the skunk ap-

proached a pan of custard that the 'coon was enjoying, and tried to stare him out. He finally nudged the 'coon in the left flank. Even that failed to work. The 'coon continued eating and the skunk moved on.

It grew so hectic that, to discourage them, I took the food from the ground and fed on a table under a hemlock, with a 150-watt spotlight. The skunks continued to come to get crumbs from under the table, and made an effort to climb. One night my son, Tom, found 'coon and 'possum in the tree and on the table, skunk on the ground. The former descended, one at a time, ignored the skunk, ate a few crumbs on the ground, and departed to their respective homes. The 'coons were consistently the bosses, and indifferent to the skunk.—ELEANOR E. DATER, *259 Grove St., Ramsey, New Jersey.* *Received 11 November 1960.*

THE HARBOR SEAL IN SOUTH CAROLINA

Recent summaries (Scheffer, SEALS, SEA LIONS, AND WALRUSES, 1958, p. 91; Miller and Kellogg, U.S. Nat. Mus., Bull., 205: 785, 1955; Hall and Kelson, MAMMALS OF NORTH AMERICA, 1959, p. 980), apparently based on Brimley (J. Mamm., 12: 314, 1931), list the southern extreme of the range of the harbor seal, *Phoca vitulina concolor*, as North Carolina in the region (35°N) between Cape Hatteras and Cape Lookout.

The southern range of this seal is now extended to the southern end of Hilton Head Island, South Carolina, or almost to the Georgia border at just north of latitude 32°N.

On 30 March 1960, Mrs. Carl Woodring found a freshly dead immature harbor seal washed up on a tidal flat in inside bay waters at the above locality. The skull and nearly complete postcranial skeleton are now preserved in the collections of the Los Angeles County Museum (LACM 13062); the skin is to be mounted for display at the yacht club on Hilton Head Island.

In addition to this record, the collections of the Charleston (S.C.) Museum contain specimens constituting two or three others for the state: One is the flat skin (ChM 55.11) of another young individual killed on 26 January 1955 in the Santee River 4 miles below the crossing of U. S. highway 17. Another is a mounted young animal (ChM 20.32) taken in Charleston Harbor "about 100 years ago" (*fide* E. Milby Burton, Museum Director). The files at the Museum contain the note that a 3½-foot live seal was caught on 1 April 1852 at Folly Beach, near Charleston, S.C. This record may be the "100 year old" mounted specimen, or a fourth for the state.

These records, as well as increasing numbers of word-of-mouth reports from fishermen and other shore dwellers I interviewed, indicate that seals (probably all harbor seals) are present, though rare, in the coastal waters of North and South Carolina. Similar, and seemingly suitable, ecological niches are found in Georgia, and the proximity of Hilton Head Island to the borders of that state make it likely that the harbor seal will be recorded from there as well. The presence of immature individuals is further evidence of a permanent population in this region.—DAVID K. CALDWELL, *Los Angeles County Museum, Los Angeles 7, California.* *Received 9 January 1961.*

GESTATION PERIOD OF THE COLLARED PECCARY

In reviewing the literature I have been unable to find an accurate gestation figure for the collared peccary, *Pecari tajacu*. Seton (LIVES OF GAME ANIMALS, 3 (2), 1925) says that it is probably less than for the common pig, which is 112 to 116 days. Taylor and Davis (Texas Game, Fish and Oyster Comm., Bull. 27, 1947) also give the period as 112 to 116 days. Davis, however (in a letter dated 17 October 1959), informs me that this figure was taken from Seton. Jennings and Harris (Texas Game, Fish and Oyster Comm., FA report No. 12, 1953) used the figures from Taylor and Davis on the gestation period when computing conception dates from known birth records. Knipe (Wildl. Bull. No. 2, Arizona Game and Fish Dept., 1958) says that the gestation period was unknown but

TABLE 1.—*Known gestation periods for captive peccaries*

Animal No.	Date of breeding	Date of parturition	Gestation period, days
1435	9 Dec. 58	1 May 59	144
"	13 May 59	3 Oct. 59	144
"	12 March 60	6 Aug. 60	148
804	8 Oct. 59	26 Feb. 59	142
"	28 Apr. 60	17 Sept. 60	143
1597	29 Feb. 60	21 July 60	144

probably between 112 to 120 days. Leopold (WILDLIFE OF MEXICO, Univ. Calif. Press, 1959) says that it is variously reported as 96, 112, and 116 days.

In 1958 a study of reproduction of the collared peccary or javelina was begun at the Arizona Cooperative Wildlife Research Unit (University of Arizona, Arizona Game and Fish Department, U. S. Fish and Wildlife Service and Wildlife Management Institute, cooperating) at Tucson, Arizona. Since 1 July 1959, this study was financed by a research grant from the National Science Foundation. I want to thank the following people for assistance with this project: C. R. Hungerford, of the University of Arizona, and students Harley G. Shaw, Richard W. Rigby, Thomas A. Eddy, Joseph P. McCraren and Paul S. Minnamon.

To obtain exact data on the length of the gestation period, captive animals of known age were kept in pens where sexes were isolated. At periodic intervals males and females were brought together. If copulation followed, the female was then isolated until parturition occurred. The data on gestation periods of three females with six litters of young obtained in this manner are given in Table 1.

From these data I conclude that the correct gestation period of the Arizona collared peccary is approximately 142 to 148 days. I conclude also that, except for Leopold's figure of 96 days, it is apparent that all of the previously published figures were probably estimates from the known gestation period of the common pig as first suggested by Seton.—LYLE K. SOWLS, *U.S. Fish and Wildlife Service, Biol. Sci. Bldg., Univ. of Arizona, Tucson.* *Received 26 September 1960.*

LATE BREEDING IN NORTHERN MICHIGAN DEER

Late breeding in northern Michigan white-tailed deer, *Odocoileus virginianus*, is not uncommon, judging from occasional reports of sightings of spotted fawns during late fall. Gordinier (J. Mamm., 29: 184, 1948) reported finding a recently born fawn near Grayling, Michigan, whose date of birth was estimated as 10 or 11 September. Occurrence of estrus from mid-January to late March has been evidenced from determination of age of fetuses (Armstrong, Am. Midl. Nat., 43: 650–666, 1950) and back-dating to probable conception date (Cheatum and Morton, J. Wildl. Mgt., 10: 249–263, 1946; Erickson, *idem*, 16: 400, 1952). In many instances, late breeding is associated with onset of sexual maturity in precocious doe fawn 6 to 8 months of age (Cheatum and Morton, J. Mamm., 23: 210, 1942).

On 18 November 1960, a spotted male fawn was found shot on the Seney National Wildlife Refuge, Schoolcraft County, in the Upper Peninsula of Michigan. The specimen was brought to the Cusino Wildlife Experiment Station at Shingleton by George W. Young. It was an extremely small fawn, considering the collection date—only 36 pounds live weight, with a hind foot (hock) measuring 340 mm and an ear length of 100 mm from tip to notch.

Based on dental criteria, I judged the fawn to be between 7 and 10 weeks of age. The temporary premolars were not completely erupted, with the lingual crests of the three

teeth measuring from 5 to 7 mm in greatest height above gum line. The anterior cusp of the first molar did not protrude above gum line, hence the fawn was not more than 10 weeks old, according to Severinghaus' classification (J. Wildl. Mgt., 13: 195–216, 1949).

The fawn's rumen contained mainly green herbage. A small quantity of partially digested milk also was present, indicating that the fawn had nursed shortly before it died. In this region of Michigan, few does are lactating during the 15–30 November hunting season. Most fawns ordinarily are weaned at 12 to 15 weeks old, or by early fall; the spotted coat usually is lost in healthy fawns at that time.

Assuming the fawn was about 8 weeks old, its date of birth was roughly 25 September, or as much as 4 months later than the normal late May–early June parturition period. Since the gestation period in white-tailed deer is approximately 200 days, the doe probably conceived about 8 March. This is very unusual, since the latest date of successful mating in adult Upper Peninsula deer is considered to be mid-January. Examination of many accidentally killed deer has revealed that approximately 95 per cent of the productive wild adult does conceive between 7 November and 13 December, a spread of 36 days.

It seems unlikely that the probable 8 March conception was the result of the onset of breeding in a precocious female fawn. Productivity in Upper Peninsula female fawns is low (ordinarily about 5.0 per cent of the yearling does we examine in late winter and early spring are pregnant). This is to be expected in view of the severe weather which normally prevails here in winter. Even large fawns must struggle for survival after the sixth month of life. Cheatum and Morton (*op. cit.*, 1946) found a considerably lower proportion of doe fawns pregnant in northern New York compared to those in the southern part of the state.

There is a greater probability that the 8-week-old fawn was produced by an adult doe experiencing a recurrence of estrus (possibly the third or fourth) following failure to conceive in earlier heats. These heat periods are spaced at approximately 28-day intervals (Cheatum, Cornell Vet., 39: 282–291, 1949). Recurrence of heat in a physically mature, vigorous doe quite likely accounts for the late birth of this fawn. This late fawning record is of considerable interest because it indicates that some northern Michigan range is of sufficiently high quality to promote successful reproduction in deer in midwinter. On the other hand, the fact that about 10 per cent of the Upper Peninsula adult females are unproductive each year suggests the possibility that the over-all range may be nutritionally deficient to some degree.—Louis J. Verme, *Michigan Dept. of Conservation, Shingleton. Received 23 January 1961.*

BREEDING NOTES ON MAMMALS IN CAPTIVITY

On 22 October 1955 the Cleveland, Ohio, Zoological Park received a pair of wild-caught common hippopotamuses, *Hippopotamus amphibius*, which had been born earlier that year and which were estimated to be about 7 months old. At that time each animal was less than 5 feet long and 3 feet high. These animals were together continuously after arrival until 7 September 1958, when their first baby, a female, was born. Allowing a mean gestation period of 237.4 days (Asdell, Patterns of Mammalian Reproduction, Comstock Publ. Co., 1946, p. 315) this would indicate that conception took place in January 1958. Estimating the birth of the parents in March 1955, it seems certain both parents were sexually mature at 3 years of age.

A male and two female blotched giraffes, *Giraffa camelopardalis*, were also received on 22 October 1955 at the Cleveland Zoological Park. They were not more than one year old at the time, all being less than 10 feet tall. They were captured in Tanganyika. Since arrival at the Zoo the three animals have been together constantly. On 23 March 1959 one of the females gave birth to a male calf. Allowing a gestation period of about 455 days (Kenneth, Gestation Periods, Tech. Comm. No. 5, Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh, 1953, p. 11; Davis, Parks and Recreation, 43: 536,

1960) this would indicate conception took place about December 1957. Thus, both parents were sexually mature at the age of 3 years.

The birth of a male Japanese black bear, *Ursus thibetanus japonicus*, at the Cleveland Zoological Park on 27 January 1961, is believed to be the first recorded birth of this subspecies in this country. The cub weighed 10¾ ounces at birth, when it was immediately taken from its cage and raised on a bottle. As of this date (27 May 1961) the cub is thriving and weighs 19 lb 12 oz. L. S. Crandall (pers. comm., 1961) advises me of the birth in 1960 of two cubs in the Opole, Poland, Zoo. T. Koga (pers. comm., 1961) lists 45 births of this subspecies in captivity in Japanese zoos between 1953 and 1961. The continental Asiatic subspecies are more frequently kept in zoos in this country and elsewhere and thus more births among these subspecies are known.

A sun bear, *Helarctos malayanus*, of unknown sex and weight was born at the Cleveland, Ohio, Zoological Park, during the night of 20 September 1960. It was partially eaten by the mother at or shortly after birth. The mother showed restlessness and discomfort during the day of birth, but the symptoms were not recognized as associated with pregnancy, which was unsuspected. The mother, up to the time that she showed the unusual behavior, was housed with another female and the sire. This mother was born in the spring of 1954 and received at the Zoo on 23 July 1954. Her estimated age when she gave birth to the cub was thus approximately 6½ years. The sire was approximately the same age and was received 10 July 1954. On 22 October 1960 it was necessary to destroy the sire, as he was suffering from an unknown illness of only a few days' duration. At autopsy this male weighed 188 lb. and appeared to be in prime physical condition. Breeding had been observed on several occasions between this male and the other female in December 1959, and in January and May 1960, but breeding was never observed between the male and the mother which had the cub. It is believed this is the fifth birth of a sun bear in captivity in this country. The previous four occurred in the San Diego Zoological Garden (Stott, Zoonooz, 27: 5–6, 1954; G. H. Pournelle, pers. comm.).—Ronald T. Reuther, *Cleveland Zoological Society, Cleveland 9, Ohio.* *Received 29 May 1961.*

SWIMMING CAPACITY OF SOME WILD MAMMALS

Bodies of water are sometimes thought to be effective barriers to the spread of populations of wild mammals. The assumption is that small mammals avoid water or if they get into water they do not survive for any significant period of time. Previous work has indicated that small laboratory animals can swim for considerable periods of time (J. Appl. Physiol., 15: 704, 1960; *ibid*, 14: 199, 1959; Am. J. Physiol., 190: 457, 1957). The opportunity presented itself for us to test the swimming capacity of several species of wild mammals obtained in Harford County, Maryland: woodchuck, *Marmota monax*; chipmunk, *Tamias striatus*; skunk, *Mephitis mephitis*; opossum, *Didelphis marsupialis*.

Individuals were forced to swim in a temperature-controlled bath until all coordinated muscular movement ceased or until it became expedient to remove the animal from the water and retest it at a later date. A wetting agent ("aerosol") was added to the water to decrease buoyancy provided by the hair. Details of the procedure appear in the references cited above.

Table 1 summarizes the results. It is clear that all the species were able to swim for significant periods of time. The chipmunk was the poorest performer; this fact may be related to its small size which would allow a relatively rapid decrease of body temperature in a 21°C bath. There is variability in maximum swimming capacity among individuals of the same species. In general, the woodchuck appeared to be the best performer, followed by the opossum, skunk, and chipmunk. Sufficient animals were not available to permit a conclusion concerning the roles of size, sex, water temperature, and body temperature in swimming performance. However, on the basis of experience with small laboratory animals it is suggested that maximum swimming time is related inversely to the rate of

TABLE 1.—*Swimming times for various mammals*

Species, sex	Bath, T°C	Swim time, min	Remarks
Woodchuck, ♂	21	72	Terminal
Woodchuck, ♂	22	185	Discontinued and retested, next
Woodchuck, ♂	24	332	Second swim 2 days after first; terminal
Woodchuck, ♀	19	480	Discontinued and retested, next
Woodchuck, ♀	25	2,460	Tested after 2 weeks' rest; terminal
Chipmunk, ♀	21	8	Terminal
Chipmunk, ♀	22	6	Terminal
Skunk, ♂	23	463	Discontinued
Skunk, ♂	24	433	Discontinued
Opossum, ♂	20	480	Discontinued
Opossum, ♂	20	210	Terminal
Opossum, ♀	22	430	Terminal

change of body temperature. In any event, the swimming times of the mammals listed are long enough to allow these species to cross moderately large water barriers.

This study was supported in part by a Public Health Service grant, MY 3235.—CHARLES G. WILBER AND GEORGE H. WEIDENBACHER, *Dept. of Biology, Loyola College, Baltimore, Maryland.* *Received 23 January 1961.*

ERRATA

In my note "*Symbos convexifrons* an invalid species" (J. Mamm., 42: 114–115, February 1961) the following necessary corrections, all on page 114, have been brought to my attention. The sentence on line 3, paragraph 2, should read: "Immediately below the skull a *right* M^3, a *left* M^2, and a *left* M^1. . . ." The statements on line 4, paragraph 3, should read: "In addition, the *right* M^3. . . . It is probable that the *left* M^1. . . ." The persistence of these errors in the original is regretted.—GEORGE E. JAKWAY, *Univ. of Nebraska State Museum, Lincoln.* *Received 13 June 1961.*

REVIEWS

Barnes, Claude T. THE COUGAR OR MOUNTAIN LION. The Ralton Co., Salt Lake City. 176 p., 2 illus., 1961. Price, $6.00 from author, 359 Tenth Ave., Salt Lake City 3, Utah.

This book represents the author's studies of the puma for more than 40 years. I say "puma" advisedly, for although the "cougar or mountain lion" appears as the title, and "mountain lion" as the page headings, "puma . . . is the one pure and unmistakable name" (p. 13), and is used regularly throughout the text. A two-page Index precedes the Introduction. There is no Table of Contents, though 16 chapters cover rather extensively the life history. Chapter 1 treats of early history and various names, in which are listed 43 English names, 18 South American native names, and 25 North American Indian names. Chapter 2 deals with Description and size; 3, Means of detecting the puma's presence; 4, Habitat relations; 5, Friends, enemies, and modes of capturing prey; 6, Times of activity, movements and postures; 7, Voice and other means of intercommunication; 8, Feeding and drinking habits, list of foods; 9, Individual characteristics, general disposition and temperament; 10, Attacks on human beings; 11, Relation of habits to survival; 12, Breeding habits; 13, Lairs, shelters and other places of resort; 14, Trapping and hunting the puma; 15, Economic status; and 16, The animal in captivity. An Appendix of three pages treats of Distribution and different forms.

Claude Barnes has lived for many years in a region that may be the last native home of the puma in the United States. He has devotedly searched literature available to him. His friendly contacts with hunters, trappers, herders, naturalists, and other men of the wilderness have brought him many puma stories. Many of these were factual; some were probably little yarns, or even big yarns. He has put them on record, and that makes them valuable. The reader, in some cases, will need to use his own sifter.

Although the format of the book is fair, it is marred by too many typographical errors. There are literature citations which are not listed in the Bibliography of 106 titles. There are also titles in the Bibliography that, in the reviewer's opinion, do not belong there, such as "DeLong, Jim. 1927. Conversation with the Author in Salt Lake City, Utah." Some publications have been missed, such as the reviewer's description of *Felis concolor schorgeri*, a subspecies also omitted from the list of races (p. 166–167).

Anyone can criticize, however, and these remarks do not imply that this volume is not well worth while, particularly as a contribution to the life history of the puma, especially in that area north of the Grand Canyon of the Colorado. It is a neat book, bound in blue cloth, of convenient size, and well written.—HARTLEY H. T. JACKSON.

Balinsky, B. I. AN INTRODUCTION TO EMBRYOLOGY. W. B. Saunders Co., Philadelphia. Pp. xiv + 562. 21 April 1960. Price, $7.75.

This is a well-written and generously illustrated textbook of embryology. The author (professor of zoology at the University of the Witwatersrand, Johannesburg, South Africa) did not like the dichotomy in embryology texts which relegated the descriptive portion of the subject to beginning texts and left to advanced treatises the physiological aspect. He has therefore "endeavored to present embryology as a single science in which the descriptive morphological approach and the experimental physiological approach are integrated and both contribute to the understanding of the ontogenetic development of organisms." In this aim, he has succeeded admirably.

There is a great deal of comparative material on the development of vertebrates and some on invertebrates. There are chapters on genetics, growth, metamorphosis, regeneration, and asexual reproduction. Literature is covered through the end of 1958 (20 pages of references) and, last but not least, *Ambystoma* is spelled correctly.

Reading this book has been a pleasurable and stimulating experience. I feel certain that studying from it will also be.—IVAN HUBER.

Cockrum, E. Lendell. THE RECENT MAMMALS OF ARIZONA: THEIR TAXONOMY AND DISTRIBUTION. Univ. Arizona Press, Tucson. Pp. viii + 276, 112 maps. 11 February 1961.

Excepting only California, Arizona claims more kinds of mammals—135 species and 155 additional subspecies—than any other of the United States. They are here neatly tabulated and annotated in a book which will be a standard reference to anyone interested in the fauna of the Southwest. The author presents it as a progress report to summarize distributional data, indicate areas of needed study, and encourage others to add to our fund of knowledge on this subject. Following a key to the species (with skin and skull characters) are accounts of each taxon. These include a synonymy; a statement of general distribution in Arizona, with maps showing locations of specimens taken; a list of specimens examined; and, in some cases, locality records from the literature. Appended are a hypothetical list of 30 species or subspecies, notes on 5 species published since completion of the manuscript, and a bibliography of 245 titles. The maps are large and clear, the typography good, and the volume generally attractive and convenient.—R. H. M.

Godfrey, Gillian and Peter Crowcroft. THE LIFE OF THE MOLE. Museum Press, London. 152 p., 31 figs., frontis. 1960. Price, 15/–.

Oddly, we have long needed a good monograph on the life history and ecology of the mole. This need is now met by this delightful and penetrating study by a British team. The field work was carried out by Dr. Gillian Godfrey, now the wife of Dr. Peter Crowcroft, mammalogist at the British Museum (Natural History). The authors have attempted "to be brief and accurate without being too dull, and above all, have tried to avoid the growing tendency of covering up for lack of knowledge with general statements in scientific jargon." They have succeeded admirably. The literature on moles the world over has been critically analyzed; field studies have been limited to the British species, *Talpa europaea*. And concerning it, the volume is a rich source of information on its general behavior, social relationships, feeding, molting, breeding and growth, life span and mortality, populations and economics. Dr. Godfrey pioneered in the use of radioactive tagging to study the movements of *Microtus*; application of this technique to moles has disclosed a great deal about their activity and habits. The bibliography lists 158 titles. The known parasites (69 species) of the mole are listed in an appendix. Chapter headings utilize charming quotations from Kenneth Grahame, probably known to more readers than any other writer on the mole.—R. H. M.

Schmidt, Herta, *Ed.* DER FLUG DER TIERE. Verlag W. Kramer, Frankfurt am Main. 164 p., 147 figs. 1960. Price, 8,50 DM.

Here is a popular but thorough treatise on animal flight by eight German authorities. It not only includes material on insects, birds and bats, but also discussions of "flight" in fishes, squids, frogs and lizards, in pterodactyls, and by means of silken webs in spiders. In the case of insects and birds, migratory patterns and flight speeds are treated as well as details of anatomy and aerodynamics. The chapter on mammals (p. 113–134), by Dr. Heinz Felten, considers not only the bats but various gliders as well, and contains reference to publications as recent as 1959. A two-page index refers only to genera mentioned. The illustrations and printing are excellent. This volume will be a useful addition to any library on general natural history.—R. H. M.

Simpson, George Gaylord. PRINCIPLES OF ANIMAL TAXONOMY. Columbia Univ. Press, New York. Pp. xii + 247, 30 figs. 23 January 1961. Price, $6.00.

A scholarly treatment of the foundations of taxonomy has long been needed. The author, presently Alexander Agassiz Professor of Vertebrate Paleontology at the Museum of Comparative Zoology, Harvard University, is eminently suited for the task, nor has he disap-

pointed us in this volume. Readers are well acquainted with his *Principles of Classification and a Classification of Mammals* (1945); this essay was revised and expanded for use as the Jesup Lectures for 1960 at Columbia University. It now appears in book form, broader in scope and with greater emphasis on fundamentals. Much that was present in the early version still persists, but there is also much that is new, and all of it has been rewritten. Careful distinctions are drawn between systematics, taxonomy, classification, and nomenclature in zoology. Taxonomy is defined as "the theoretical study of classification, including its bases, principles, procedures, and rules." This subject is skillfully developed with consideration of order in nature, taxonomic evidence available, the historical development of taxonomy since Linnaeus, and the relationship of taxonomy and evolution. Higher and lower categories are treated in detail. Examples are drawn principally from mammals, but also from metazoans generally, and many hypothetical illustrations are employed. One reads (p. 30) that "priority has upset the stability of nomenclature almost as much as it has promoted it." There is much that is provocative in this volume; all of it is written with clarity and deep insight. No serious zoologist can neglect to become versed with the material herein.—R. H. M.

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COMMENTS AND NEWS

ZOOLOGICAL NOMENCLATURE

The following is abstracted from a communication recently received from W. E. China, Assistant Secretary to the International Commission on Zoological Nomenclature:

Notice of proposed use of Plenary Powers in certain cases (A. [n.s.] 48).

(12) Suppression of the specific name *planiceps* (*Hyracodon*) Scott & Osborn, 1887. Z.N. (S.) 1438.

Full details will be found in the *Bull. Zool. Nomencl.*, 18 (3), 16 June 1961. Comments, in writing and in duplicate, are invited from any zoologist, as soon as possible and, in any case, before 16 December 1961. Those received in time will be published in the *Bull. Zool. Nomencl.* They should be addressed to The Secretary, International Commission on Zoological Nomenclature, c/o British Museum (Natural History), Cromwell Road, London, S.W. 7, England.

BIOMETRICS IN ECOLOGY

More and more, the application of statistics is proving useful in biological investigations. Ecologists in particular will be interested in the recent 315-page report TID-3908, "An annotated bibliography of the uses of statistics in ecology," by Vincent Schultz, ecologist with the Environmental Sciences Branch of the U.S. Atomic Energy Commission, 1961. This represents an extensive search for the use of statistics in 31 periodicals. One of these was the *Journal of Mammalogy*, from which statistical data are indexed under 56 headings and 206 articles are cited from 1920 to 1958. Copies are available, priced at $3.00, from the Office of Technical Services, Department of Commerce, Washington 25, D.C.

TAYLOR RECOGNIZED

It is a pleasure to record that, as a highlight of the 26th North American Wildlife and Natural Resources Conference, the Wildlife Society awarded its Aldo Leopold Memorial Medal to Dr. Walter P. Taylor of Claremont, California, for his "distinguished service and outstanding accomplishment to the cause of conservation." A charter member of our Society, Dr. Taylor served as the first treasurer and as president from 1940–42, and was elected an honorary member in 1954. He worked as a biologist for 35 years with the Bureau of Biological Survey and its successor, the U.S. Fish and Wildlife Service. He has published over 300 works on ecology, zoology and natural resources conservation, and has co-authored books on THE BIRDS OF WASHINGTON and DEER OF NORTH AMERICA. As a teacher and lecturer in conservation education, he has been affiliated with several universities and is known to many high school and college groups. Our congratulations to Dr. Taylor for this well-deserved recognition.

POUGH HONORED

At a meeting of The Garden Club of America in New York City on 11 April, the Frances K. Hutchinson Medal was awarded to Richard H. Pough for service in conservation. Mr. Pough, a member of this Society since 1949, has been a crusader for the preservation of our natural resources for more than 25 years. He has been active in the Nature Conservancy, the National Parks Association, the Boone and Crockett Club, and the John Burroughs Association, to name but a few. He planned and supervised construction of the Hall of North American Forests at the American Museum of Natural History, and has authored the popular *Audubon Field Guides*. Known primarily as a conservationist, ecologist and ornithologist, he well deserves to join the ranks of such personages as Louis Bromfield, Rachel Carson and Walt Disney.

GRANTS FOR FAUNAL STUDIES

The Theodore Roosevelt Memorial Fund has recently been established to "help provide the necessary means of encouraging studies on the North American fauna to which Theodore Roosevelt, 26th President of the United States, devoted so much of his time and energy." Grants will be made for research in any phase of wildlife conservation or in related fields of natural history. Preference will be given to younger scientists, particularly to graduate students. Although applications for the year 1961 were closed on 1 May, interested parties should plan ahead for another year. Address inquiries to the Director, American Museum of Natural History, Central Park West at 79th St., New York 24, N. Y.

MUSEUM RESEARCH

The Karl P. Schmidt Fund has modest sums available to assist persons wishing to study at the Chicago Natural History Museum. Grants will be made for study in any of the four fields encompassed by the museum: anthropology (with a natural history orientation), botany, geology (including paleontology), and zoology. An applicant should describe the study proposed in brief terms, state the length of time he wishes to study at the museum and the amount of money needed, and name one reference. Mail applications to: Chairman, The Karl P. Schmidt Fund, c/o Chicago Natural History Museum, Roosevelt Road and Lake Shore Drive, Chicago 5, Illinois.

NEW EDITOR OF JOURNAL

With the completion of Volume 42 in November, I end a five-year period as Editor of your Journal. This has been a pleasant and profitable experience for me and, I trust, for our Society. Without your help the work would have been far more arduous. In handing on the blue pencil, I particularly wish to express my gratitude to my Editorial Committee, for its faithful, diligent and efficient service at all times; to the Index Committee, whose voluntary work in preparing the annual index has greatly lessened the work of this office; and to our many authors for their forbearance and understanding, when at times there was just cause for complaint. I trust you will extend the same cooperation to my successor, in order that the *Journal of Mammalogy* may continue, as a leading publication in its field, to serve the interests of the Society.

Effective at once, manuscripts for publication, books for review, special notices and other communications should be addressed to the new Editor, Dr. James R. Beer, Dept. of Entomology and Economic Zoology, University of Minnesota, St. Paul 1, Minnesota. Our best wishes go to Dr. Beer on assuming his new duties.—RICHARD H. MANVILLE.

DEATHS REPORTED

Rudolph M. Anderson, Honorary and Charter Member, 21 June 1961

Tappan Gregory, Life Member, 29 April 1961

George O. Hendrickson, 19 March 1961

Henry Hull Collins, Jr., 26 May 1961

Raymond M. Selle, 31 May 1960

Harold P. Pratt, 16 March 1961

SENIOR FELLOWSHIPS

Announcement has been received from the National Science Foundation of a program of Senior Postdoctoral Fellowships for research in science, designed for citizens and nationals of the United States who have held a doctoral degree in one of the basic sciences for at least five years. General information and application materials may be obtained from the Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Completed materials must be received by the Division not later than 9 October 1961. Fellowships will be awarded on 11 December 1961.

INDEX AVAILABLE

The new Ten-Year Index to the *Journal of Mammalogy*, covering volumes 31–40, 1950–1959, is now on sale, clothbound only, priced at $5.00 per copy. Orders may be placed through the Secretary–Treasurer.

REPRINT PRICES

It has become necessary for the Allen Press to increase the price of reprints from the *Journal*. New rates, with an added charge of $8.90 for 100 covers, $4.60 for each additional 100 covers, are as follows:

	1 page	*2 pages*	*4 pages*	*8 pages*	*12 pages*	*16 pages*
100 copies	$5.65	6.98	9.90	12.65	15.60	18.55
Each extra 100	2.80	3.80	5.00	8.00	10.40	13.80

PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the Editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Notices will be continued in each issue unless cancellation is received a month before publication or unless specified in original order. Bills will be rendered by the Secretary–Treasurer following publication.

FOR SALE—*North American Faunas* No. 1 to 56 (except 23, 28, 29, 39, 40 and 50), in good condition; No. 7, 17, 27 and 49 bound. Mrs. Norma C. Williams, 6620 Lee Highway, Arlington 13, Va.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

URGENTLY NEEDED—*Serum of foreign pinnipeds* for a comparative study involving electrophoretic and immunologic work on pinnipeds of the world. Directions for preservation and shipping sent on request; we assume shipping costs. Murray L. Johnson, Museum of Natural History, University of Puget Sound, Tacoma 6, Washington, U. S. A.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

ALL-PETS MAGAZINE is written for hobbyists, breeders, fanciers and people engaged in pets for profit; covers all unusual livestock kept as pets, plus aquaria, cage and aviary birds, cats and dogs; subscription $3.50 per year. Manuscripts solicited from ASM members. Established 25 years, circulation world-wide, 80 pages and up monthly. We also publish books on pet livestock; some 80 titles now. National distributors of some 350 books on pets. Write for free book circular to Frank Dittrich, 139 Darling Place, Fond du Lac, Wisconsin.

WANTED—*Correspondents* anywhere with interest in rodents or other small mammals. Also interested in swapping southwestern U. S. species for those from other areas. Niles H. Hagedorn, 44628 N. Gingham Ave., Lancaster, Calif.

NOTICE—Because of research commitments, I am no longer able to collect live desert rodents for commercial sale. Future orders and inquiries should be sent to the *Arizona Biological Supply Company*, 964 Calle Milu, Tucson, Arizona. This company was founded by me, but its expanded activities are now conducted by a group of graduate students at the University of Arizona. They will appreciate your patronage.—Keith E. Justice.

MAMMALIAN HIBERNATION: Proceedings of the First International Symposium on Natural Mammalian Hibernation. C. P. Lyman and A. R. Dawe, editors. *Bull. Mus. Comp. Zool.*, Vol. 124, 1960, 549 pages. Twenty-six papers including ones by Eisentraut, Johansson, Kalabukov, Kayser, Popovic, Sarajas and Suomalainen. Panel discussions by Adolph, G. H. Bishop, Fisher, Griffin, Luyet and Prosser. $3.00 paperbacked, $4.50 clothbound. Order from Museum of Comparative Zoology, Harvard University, Cambridge, Mass.

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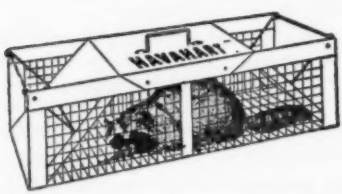

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